Atlantic Billfish Fishery Management Plan Amendment

Chapter 4
HABITAT PROVISIONS AND ESSENTIAL FISH HABITAT

4.0 Introduction 4-2

4.1 Description of Stocks in the Management Unit 4-28

4.2 Habitat Types and Distributions 4-10
4.2.1 Atlantic 4-11
4.2.2 Gulf of Mexico 4-19
4.2.3 U.S. Caribbean 4-25

4.3 Life History and Essential Fish Habitat Descriptions 4-29
4.3.1 Introduction 4-29
4.3.2 Species Accounts and Essential Fish Habitat 4-35
Essential Fish Habitat Maps for Section 4.3 4-46
Summary Tables of Life History and Habitat Association 4-62

4.4 Threats to Essential Fish Habitat 4-66
4.4.1 Fishing Activities That May Adversely Affect EFH 4-67
4.4.2 Non-Fishing Threats to EFH 4-71
4.4.2.1 Marine Sand and Minerals Mining 4-74
4.4.2.2 Offshore Oil and Gas Operations 4-74
4.4.2.3 Coastal Development 4-77
4.4.2.4 Dredging and Disposal of Dredge Material 4-81
4.4.2.5 Agriculture (and Silviculture) 4-82
4.4.2.6 Aquaculture and Mariculture 4-84
4.4.2.7 Navigation 4-84
4.4.2.8 Marinas and Recreational Boating 4-86
4.4.2.9 Ocean Dumping 4-87
4.4.3 Cumulative Impacts 4-88

4.5 Research and Information Needs 4-90

4.6 Review and Revision of EFH Components 4-92

References for Chapter 4 4-93

4.0 Introduction

Chapter 4 identifies and describes habitats, including essential fish habitat (EFH) for billfish covered by this FMP amendment, on behalf of the Secretary of Commerce, in accordance with the Magnuson-Stevens Act. It describes how each of the regulatory requirements for the EFH provisions have been addressed and the distribution of billfish habitats for the jurisdictional area This chapter also contains all of the mandatory elements for EFH identification, description and conservation, including explicit descriptions of the locations and characteristics of EFH for each managed species in text with referenced tables and maps. In addition, it considers threats to EFH from fishing activities and potential threats to EFH from non-fishing activities, and identifies options for the conservation and enhancement of billfish EFH that should be considered in the planning of projects that might adversely affect those habitats. These measures are representative of the conservation and enhancement measures that may be recommended by NMFS during consultation with Federal action agencies, as required by section 305(b) of the Magnuson-Stevens Act, on projects that may adversely impact billfish EFH, although specific conservation measures will be developed on a case-by-case basis. NMFS authority includes the direct management of activities associated with fishing for marine, estuarine and anadromous resources; NMFS' role in Federal interagency consultations with regard to non-fishing threats is, more often than not, advisory. This document assumes no new authority or regulatory role for NMFS in the control of non-fishing activities beyond the statutory requirements to recommend measures to conserve living marine resources, including their habitats.

Regulatory Requirements

Section 303(a)(7) of the Magnuson Stevens Act, 16 U.S.C. §§ 1801 *et seq*., as amended by the Sustainable Fisheries Act in 1996, requires that FMPs describe and identify EFH, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat.

The Magnuson-Stevens Act provides the following definition: *"The term 'essential fish habitat' means those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity."* (16 U.S.C. § 1802 (10)) The EFH EFH regulations (at 50 C.F.R. 600 Subpart J) provide additional interpretation of the definition of essential fish habitat: *"'Waters' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate; 'substrate' includes sediment, hard bottom, structures underlying the waters, and associated biological communities; 'necessary' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle."*

Description and Identification of EFH

The EFH regulations require that EFH be described and identified within the U.S. Exclusive Economic Zone (EEZ) for all life stages of each species in a fishery management unit. FMPs must describe EFH in text and tables that provide information on the biological requirements for each life history stage of the species. According to the EFH regulations, an initial inventory of available environmental and fisheries data sources should be undertaken to compile information necessary to describe and identify EFH and to identify major species-specific habitat data gaps. Available information should be evaluated through hierarchical analysis based on: 1) presence/absence of the species in specific habitats; 2) habitat related densities or relative abundances; 3) growth, reproduction, or survival rate comparisons between habitats; and 4) habitat dependent production rates (quantified by habitat quantities, qualities and specific locations). This information should be interpreted with a risk-averse approach to ensure that adequate areas are protected as EFH for the managed species. In this chapter habitats that satisfy the criteria in the Magnuson-Stevens Act and the EFH regulations have been identified and described as billfish EFH.

In order to fulfill the requirements of the EFH regulations and the Magnuson-Stevens Act, NMFS scientists in the Southeast Fisheries Science Center (SEFSC) conducted a complete review of the most recent information available. Their review covered the life histories of all billfish fishery species in the management unit, with an emphasis on the factors that influence distribution of the species. NMFS scientists made full use of the latest annual reports to ensure that the habitat information utilized was up-to-date. Additional information was available in the form of fishery independent sources (directed research investigations) and fishery dependent sources (capture and bycatch reporting); although the location information is suitable for Geographic Information System (GIS) based spatial analysis of distributions, there is a general lack of accompanying environmental or habitat data with which to define habitat tolerances or preferences. All of the written accounts detailing billfish life history, distribution and habitat use for billfish were submitted to independent reviewers who provided comments on the draft manuscripts. These comments were considered and assessed by the scientific authors and included, as appropriate. We are grateful to these reviewers for their excellent contributions to this chapter, ensuring that the information is complete and up-to-date.

This chapter contains all of the required provisions as specified in the EFH regulations, covering all life stages of the species managed under this FMP amendment for which information is available.

Fishing Activities That May Adversely Affect EFH

The EFH regulations and the Magnuson-Stevens Act require the fishery management councils and NMFS, on behalf of the Secretary of Commerce, to minimize adverse effects on EFH from fishing activities to the extent practicable. Adverse effects from fishing may include physical, chemical, or biological alterations of the substrate, and loss or injury to benthic organisms, prey species and their habitat, and other components of the ecosystem. Based on an assessment of the potential adverse effects of all fishing equipment types used within an area designated EFH, the Council should act if there is evidence that a fishing practice is having an identifiable adverse effect on the EFH.

In order to determine whether billfish fishing causes adverse impacts on EFH, an assessment was made of the gears and practices, as described in the proposed gear rule [63 FR 30455, June 4, 1998]. Impacts of billfish and other HMS and non-HMS fishing gears and practices were analyzed by examining published literature and anecdotal evidence of potential impacts or comparable impacts from other fisheries (Section 4.4). Based on this initial assessment, the fishing methods of the billfish fisheries appear to have limited impact on billfish EFH. There is the possibility, however, that other (non-HMS) fisheries may adversely impact billfish EFH, although the degree of that impact is impossible to ascertain from the data currently available. This question needs to be more closely examined and addressed through coordination with other fishery management authorities. No new management measures, and therefore no regulations, are proposed. At this time there is no evidence that billfish fishing practices are causing adverse impacts on the EFH of billfish, although conservation recommendations are included to mediate the possible effects of fishing practices listed in Section 4.4. NMFS is aware that other options may be required in the future as a greater understanding of the impacts of fishing gear on fish habitat is gained. Options that may be necessary could include fishing gear or practice restrictions, or time/area closures, harvest limits on the take of species that provide structural habitat or of prey species. Areas that are currently closed to fishing should be used as experimental control areas to research the effects of fishing gears on habitat or fishing intensity on the ecosystem.

Non-fishing Activities That May Adversely Affect EFH and Respective Conservation Measures

Section 600.815 (a)(5) of the EFH regulations requires that FMPs identify non-fishing related activities that may adversely affect EFH of managed species, either quantitatively or qualitatively, or both. In addition, Section 600.815 (a)(7) requires that FMPs recommend conservation measures describing options to avoid, minimize, or compensate for the adverse effects identified.

Broad categories of activities that may adversely affect billfish EFH include, but are not limited to: 1) actions that physically alter structural components or substrate, e.g., dredging, filling, excavations, water diversions, impoundments and other hydrologic modifications; 2) actions that result in changes in habitat quality, e.g., point source discharges, activities that contribute to non-point-source pollution and increased sedimentation, introduction of potentially hazardous materials, or activities that diminish or disrupt the functions of EFH. If these actions are persistent or intense enough they can result in major changes in habitat quantity, as well as quality, conversion of habitats, or in complete abandonment of habitats by some species.

As required under the EFH regulations, this chapter identifies activities having the potential to adversely affect billfish EFH. In many cases these activities are regulated under particular statutory authorities. As long as they are regulated within those guidelines, their potential to adversely affect EFH may be reduced, although not necessarily eliminated. Many of the standards that are used to regulate these activities are based on human health needs and do not consider long-term impacts on fish and fish habitats. Additionally, if the activity fails to meet or is operated outside its permitted standards, it may adversely affect EFH. The EFH regulations require NMFS and the Councils to identify actions with the *potential* (emphasis added) to adversely affect EFH, including its biological, chemical and physical characteristics. The EFH regulations also recommend the examination of cumulative impacts on EFH. It is possible that many permitted actions operating within their regulatory bounds may cause adverse impacts on EFH. This chapter lists a broad range of activities to ensure that their potential to adversely affect billfish EFH will be adequately considered.

The review of billfish habitat use undertaken for this chapter identified both benthic and water column habitats in coastal and offshore areas as EFH, although in many cases the particular habitat characteristics that control species habitat use are not clearly identified. Many of these factors seem to be related to water quality, e.g., temperature, salinity, dissolved oxygen. Therefore, water quality degradation is a primary focus in Section 4.4.2. When analyzing the impacts that water quality changes can have on billfish EFH, it is important to examine all habitats. Although EFH for billfish includes offshore areas, these distant habitats are affected by actions that occur in coastal habitats (both terrestrial and aquatic) and adjacent estuaries. Billfish are known to aggregate over submarine canyons or along river plumes; these physiographic features can serve as conduits for currents moving from inshore out across the continental shelf and slope, redistributing contaminants from the nearshore realm to offshore habitats. Until the precise zones of influence from various river and coastal discharges can be delineated, a precautionary view should be taken in order to protect the integrity of billfish EFH and the sustainability of billfish fisheries.

In addition to identifying activities having the potential to adversely affect EFH, the Magnuson-Stevens Act and the EFH regulations require the inclusion of measures to conserve and enhance EFH. Each activity discussed in this chapter is followed by conservation measures to avoid, minimize or mitigate its adverse effects on EFH. These include examples of both general and specific conservation measures that might be appropriate for NMFS to recommend when consulting on similar proposed activities. In some cases the measures are based on site-specific activities, in others the recommendations represent broad policy-type guidelines. During EFH consultations NMFS will evaluate each project based on its merits and potential threat to EFH, and the appropriate conservation measures will be assessed at that time. The Federal action agency with the statutory authority to regulate the proposed action must weigh all comments and decide on the appropriate action, modifications or mitigation before proceeding with a project. The conservation measures included in this amendment provide examples of NMFS' recommendations that potentially could be made regarding particular projects. They are intended to assist Federal and state agencies and other entities during the planning process when minimization of adverse impacts on EFH can most effectively be incorporated into project designs and goals.

Maps geographically depicting threats to EFH should be included in an FMP/Amendment. At the present time, however, the information for producing accurate maps depicting threats to billfish EFH is not available. The use of GIS for mapping EFH distributions will allow the addition of this information as it becomes available.

Cumulative Impacts Analysis

The EFH regulations require that to the extent feasible and practicable FMPs should analyze how fishing and non-fishing activities influence habitat function on an ecosystem or watershed scale. At this time the technology is not available to provide a site-specific analysis of cumulative impacts for each area that has been identified as EFH for billfish, although the use of GIS technology to map EFH for this amendment will facilitate the investigation of cumulative impacts in the future. A discussion of habitat loss arising from cumulative impacts is included in Section 4.4.3 to illustrate the types of effects that will be investigated in the future when the techniques and data become available.

Habitat Areas of Particular Concern

The EFH regulations suggest that FMPs should identify Habitat Areas of Particular Concern (HAPC) within EFH for habitats that satisfy the criteria of being sensitive or vulnerable to environmental stresses, rare, or particularly important ecologically.

No HAPCs for billfish are identified at this time. However, as more information becomes available, it is possible that such areas may be designated in the future.

Research and Information Needs

The EFH regulations suggest that FMPs should contain recommendations, preferably in priority order, for research efforts that have been identified as necessary for carrying out the EFH management mandate.

This chapter contains a listing of research and information needs that should be addressed in order to improve the ability to conserve and manage habitat concerns under the EFH mandate. These efforts vary from the gathering of additional information from diverse sources in order to better map the distributions of EFH to long range research projects that will provide additional life history information, better defining the environmental parameters that influence the distribution of billfish.

Habitat Goals

Information presented in this chapter is consistent with the goals of habitat conservation. The chapter further proposes the following guidance for future NMFS actions regarding the management of billfish fishery resources:

> Recognizing that all species are dependent on the quantity and quality of their essential habitats, it is the goal of the NMFS Highly Migratory Species Management Division to:
>
>> Conserve, restore and improve habitats upon which commercial and recreational marine fisheries depend, to increase their extent, and to improve their productive capacity for the benefit of present and future generations.
>
> This policy is supported by two general objectives:
>
>> a. Maintain the current quantity and productive capacity of habitats that support important commercial and recreational fisheries, through development of a better understanding of the dynamics of habitat that influence biological productivity, and the pursuit of a hierarchical policy of avoidance, minimization and compensatory mitigation for actions that cause adverse effects on essential fish habitats.
>>
>> b. Restore, rehabilitate or enhance the productive capacity of habitats already degraded to increase fishery productivity for the benefit of the resource and the Nation.

4.1 Description of Stocks in the Management Unit

Billfish are classified into the family Istiophoridae in the suborder Scombroidei, which also includes the swordfish (family Xiphiidae) and tunas (family Scombridae). They are epipelagic, being found primarily in the upper 300 to 600 ft (100 to 200 m) of open-sea areas, and neritic (utilizing the waters over the continental shelf), and are also found in coastal waters seasonally. These fishes are some of the largest and fastest predators in the sea and display behavioral, anatomical, and physiological adaptions for a mobile open-sea existence.

Billfish are distinguished by a long bill, developed as a forward growth of the upper jaw. This bill differs from that of the swordfish in that it is round rather than flat in cross section, and rough rather than smooth. At its maximum extent, it is generally less than one-quarter the total length of the fish. Billfish capture prey fish by swimming through schools while slashing the bill back and forth, stunning or injuring the prey in the process. Marlin have also been observed knocking prey such as small tuna into the air and spearing tuna prior to swallowing them. Spearing may also be used for defensive purposes or during territorial encounters - broken bills have been found embedded in boat hulls and other objects (Moyle and Cech, Jr., 1996; Helfman *et al.*, 1997).

Billfish move thousands of kilometers annually throughout the world's tropical, subtropical, and temperate oceans and adjacent seas. As adults and juveniles, they feed at the top of the trophic food web, meaning that their food resources are patchily distributed and occur at relatively low densities compared to prey for more generalized feeders. The foraging and movement patterns of billfish reflect the distribution and scarcity of appropriate prey in the open seas; these species therefore must cover vast expanses of the ocean in search of sufficient food resources (Helfman *et al.*, 1997). Consequently the distribution of billfish is often correlated with areas where higher densities of prey are found, such as current boundaries, convergence zones, and upwelling areas.

Body shapes and physiological mechanisms of billfish reflect the adaptations to continual and fast swimming, anatomical characteristics that are shared with other large pelagic species. They are counter shaded and silvery, features which provide camouflage in the pelagic realm. These fishes have streamlined bodies that are round or slightly compressed in cross section (fusiform), and stiff, deeply forked (lunate) tails that minimize drag. Streamlining is enhanced by depressions or grooves on the body surface into which the fins can fit during swimming. They have efficient respiration and food conversion capabilities and a high percentage of red muscle and lipids necessary for continuous and rapid swimming. Billfish have evolved a special respiratory mode known as ram gill ventilation that is believed to conserve energy compared to the more common mechanism whereby water is actively pumped across the gills. Ram gill ventilation requires that the fish swim continuously with the mouth open while water flows across the gill surfaces, but it offers advantages in efficiency suited to the highly mobile lifestyle of the billfish (Helfman *et al.*, 1997).

Billfish also exhibit physiological adaptations that enable them to extend their hunting or feeding ranges. Modified eye muscles, that have lost the ability to contract, produce heat when stimulated by the nervous system, locally warming both the brain and eye tissues. This modification allows billfish to hunt in cold (generally deeper) water without experiencing a decrease in brain and visual function (Helfman *et al.*, 1997).

Billfish are dioecious (the sexes are separate), with varying degrees of sexual dimorphic growth in the various species. Females are generally larger than males, although there are no morphological features or color patterns evident to differentiate the sexes. Spawning occurs seasonally. Evidence suggests that blue marlin, white marlin and sailfish spawn in the warmer months and that longbill spearfish spawn during the winter months. Reproductive females spawn more than once and probably up to four times a year, while mature males are capable of spawning throughout the year (de Sylva and Breder, 1997). Based on ichthyoplankton sampling for eggs and larvae, which are difficult to identify to species, spawning grounds are believed to be somewhat constant year-to-year. Fertilization is external and involves the release of millions of eggs from each female per year (e.g., a 33.4 kg female may shed up to 4.8 million eggs in three batches during one spawning season (Jolley, 1977 in Nakamura, 1985)). Larvae tend to be fast growing, which has compounded the difficulty of identifying and characterizing each life stage.

4.2 Habitat Types and Distributions

The billfish included in this FMP amendment - blue marlin, white marlin, sailfish, and longbill spearfish - traverse large expanses of the world's oceans, straddling jurisdictional boundaries. Although many of the species frequent other oceans of the world, the Magnuson-Stevens Act only authorizes the description and identification of EFH in Federal, state or territorial waters, including areas of the U.S. Caribbean, the Gulf of Mexico and the Atlantic coast of the United States to the seaward limit of the U.S. Exclusive Economic Zone (EEZ). These areas are connected by currents and water patterns that influence the occurrence of billfish at particular times of the year. On the largest scale, the North and South Equatorial currents bathe the U.S. Caribbean islands. The North Equatorial Current continues through the Caribbean Basin to enter the Gulf of Mexico through the Yucatan Straits. The current continues through the Florida Straits to join the other water masses (including the Antilles Current) to form the Gulf Stream along the eastern coast of the United States. Variations in flow capacities of the Florida Straits and the Yucatan Straits produce the Loop Current, the major hydrographic feature of the Gulf of Mexico. These water movements in large part influence the distribution of the pelagic life stages of billfish.

Analysis of the life histories and distributions of the billfish managed under this FMP amendment led to the identification of various habitats, essential to the species, that have been highlighted whenever possible as EFH in the text descriptions found in Section 4.3 of this chapter. Billfish distributions are most frequently associated with hydrographic features such as density fronts between different water masses. The scales of these features vary. For example, the river plume of the Mississippi River extends for miles into the Gulf of Mexico and is a fairly predictable feature, depending on the season. Fronts that set up over the De Soto Canyon in the Gulf of Mexico, or over the Charleston Bump or the Baltimore Canyon in the mid-Atlantic, may be of a much smaller scale. The locations of many fronts or frontal features are statistically consistent within broad geographic boundaries. These locations are influenced by riverine inputs, movement of water masses, and the presence of topographic structures underlying the water column, thereby influencing the habitat of billfish.

In determining EFH for billfish, consideration has been given to habitat associations for all life stages. Although they typically range throughout open ocean waters, some billfish also move inshore at some time during their life cycles. Because of the seasonal use of these habitats, in addition to open ocean habitats, inshore areas are described in terms of distribution, size, depth, freshwater inflow and habitat types (e.g., bottom types) available. As additional information is accumulated this section will be expanded to more fully characterize the links between the managed species and specific habitat characteristics. The following sections describe the distribution of the habitats that are utilized by billfish, including those that are considered to be EFH. They include descriptions of continental shelf/slope features and the dominant current patterns in-so-far as they may influence the existence and persistence of hydrographic fronts. Much of the information is from synthesis documents and references; the original sources are cited in these (Appeldoorn and Meyers, 1993; MMS, 1992; 1996).

4.2.1 Atlantic

For identification of billfish EFH under the Magnuson-Stevens Act, the Atlantic region of the Federal jurisdiction spans the area between the Canadian border in the north and the Dry Tortugas in the south. It includes a diverse spectrum of aquatic species of commercial, recreational, and ecological importance. The distribution of marine species along the Atlantic seaboard is strongly affected by the cold Labrador Current in the northern part, the warm Gulf Stream in the middle and southern portions of the region, and generally by the combination of high summer and low winter temperatures.

For many species Cape Hatteras forms a fairly strong zoogeographic boundary between the mid- and south Atlantic areas, while the Cape Cod/Nantucket Island area is a somewhat weaker zoogeographic boundary in the north. Considering the region as a whole, there are four fairly distinct biological regimes:

- Arcadian/Scotian Province - from the Canadian border (jurisdictionally) to just south of Cape Cod (north Atlantic);
- Virginian Transition Province - from Cape Cod to Cape Hatteras;
- Carolinian Province - Cape Hatteras to just south of Cape Canaveral; and
- **Floridian/Caribbean Province** - just north of Miami to the Dry Tortugas.

For the purposes of this chapter, the Atlantic region is divided into three zones - North Atlantic, mid-Atlantic and south Atlantic - for general descriptions of habitats, combining regimes 3 and 4 above; however, species distributions and ecological roles are influenced by the larger scale environments (province). The boundaries between these zones are fluid and do not limit either the movement of the highly migratory billfish or the water masses that flow through each region. All of these provinces have resident and migratory species that make up the complex fish assemblages. The mid-Atlantic area from Cape Cod to Cape Hatteras represents a transition zone between northern cold-temperate waters of the north and the warm-temperate waters to the south. Water temperatures in the mid-Atlantic vary greatly by season. Consequently, many of the fish species of importance in the mid-Atlantic area, including billfish, migrate seasonally, whereas the major species in the other three areas are typically resident throughout the year (MMS, 1992; 1996).

Continental shelf/slope features: (Material in this section is largely a summary of information in MMS, 1992; 1996. Original sources of information are referenced in those documents)

North Atlantic Shelf Features: The circulation patterns of the Gulf of Maine and Georges Bank dominate the oceanographic regime of the northeastern Atlantic shelf. The Gulf of Maine is a deep indentation in the continental shelf, with irregular bottom topography. Its bottom consists of three major basins and many smaller ones separated by numerous ridges and ledges. It is a semi-enclosed sea, with Nova Scotia as its northern and eastern boundary and the northeastern U.S. coast as its western boundary. Georges and Browns Banks separate the Gulf of Maine from the Atlantic Ocean.

Georges Bank is a large, relatively shallow topographic high that lies southeast of the Gulf of Maine, its seaward edge comprising part of the shelf break in the north Atlantic. Georges Bank is consistently one of the most productive habitats for plankton in the world. The tidal and oceanographic current regimes in the area and Georges Bank's proximity to deep slope water allow upwelling events to occur that transport nutrient rich deep water to the shallow, euphotic areas of the bank. This provides increased primary productivity that benefits higher trophic level fish and shellfish species. On the seaward side, Georges Bank is cut by numerous submarine canyons. The outcroppings and hardened sediments of the canyons provide increased attachment substrate for deeper-water epifaunal organisms (animals attached to the substrate) and allow complex faunal communities to form.

From the Scotian Shelf in the north, past Georges Bank and through the Mid-Atlantic Bight, a shelf-slope front exists. This hydrographic boundary separates the fresher, colder, and more homogeneous waters of the shelf and the horizontally stratified, warmer, and more saline waters of the continental slope. The shelf-slope front may act as a barrier to shelf-slope transfer of water mass and momentum.

From Nova Scotia to Cape Hatteras, 26 large valleys which originate on the shelf cut into the sea floor downward across the slope and rise. The current regimes in these submarine canyons promote significant biological productivity and diversity. Tidal oscillations on the shelf, combined with the intermittent influence of Gulf Stream warm core rings on the slope, dominate currents and influence sediment transport in the canyons. The canyon topography directs the mean shelf current below 100 m (328 ft) into the canyon rather than along the shelf break. Peak currents occur near the canyon heads and flow down the canyon, while currents at intermediate depths flow up the canyon. These patterns suggest a circulation that may trap sediments in the canyon heads and produce conditions conducive to front development. Billfish are known to aggregate in the areas where these fronts form, most likely as productive feeding grounds.

Mid-Atlantic Shelf Features: The mid-Atlantic region is between the colder, arctically influenced environments to the north and the warm, sub-tropical systems to the south. This area reflects a transition zone between the glacial till, rocky shores and steep gradients of the New England states and the wide, gently sloping geology of the coastal plains of the southeastern United States. The mid-Atlantic is a highly diverse, often seasonally-utilized zone for many aquatic and terrestrial species. Billfish, notably white marlin and sailfish, move into or through this zone during the warmer seasons of the year. A major biogeographic boundary for marine organisms on the continental shelf occurs at Cape Hatteras where the Gulf Stream turns eastward, separating the temperate and tropical provinces. A sharp faunal break is less obvious on the slope, although this area does appear to be a region of rapid faunal change.

The mid-Atlantic shelf is relatively flat, but there is a ridge-and-swale (hill-and-valley) topography that may be a result of present oceanographic conditions or remnant barrier beaches. The shelf typically is composed of a thin surface layer of poorly sorted shell and medium-to-coarse grained sand that overlays clay sediments. In general, the surface sediments grade from medium-grained sands inshore to finer sediments at the shelf break. Coarse-grained sediments generally support large quantities of animals, including many sessile forms. Fine-grained sediments usually contain a depauperate fauna, and attached organisms are uncommon. Within the Mid-Atlantic Bight, the quantity of fauna decreases markedly from north to south and from shallow to deep water.

Offshore the eastern United States, the six major submarine canyons - Block, Hudson, Wilmington, Baltimore, Washington, and Norfolk Canyons - occur within 150 km of shore. They begin in waters of little more than 100 to 200 m (325 to 650 ft) and descend to 2,000 m (6,500 ft). Numerous smaller submarine canyons, V-shaped valleys that resemble terrestrial canyons of fluvial origin, cut into the continental slope along the Atlantic coast. These canyons become less rugged and numerous to the south with the last significant one, Norfolk Canyon, occurring off Chesapeake Bay.

Canyon topography tends to be rugged and diverse, with numerous outcrops providing a greater amount of substrate for faunal attachment than is typically found along the remainder of the continental margin. Submarine canyons also appear to function similar to terrestrial watersheds, concentrating water, sediments, and dissolved and particulate nutrients which flow off the shelf. This characteristic can tend to increase the zone of influence of estuarine and coastal activities into shallow or deep shelf waters, potentially affecting the quality of billfish EFH. The heterogeneity of canyon environments results in communities that are generally richer biologically than those on the adjacent shelf and slope. Additionally, the species assemblages inhabiting the head, axis, and lower walls of large submarine canyons are frequently different from those found on the continental slope. Canyon assemblages are often dominated by large populations of sessile filter feeders, whereas slope assemblages usually consist of sparse mobile carnivore/scavenger populations.

On the north and mid-Atlantic continental slope and rise, the epifauna is controlled by a combination of depth and topography (canyon versus slope gradient). On the south Atlantic slope and rise, however, the epifauna appears to be controlled by a more complex oceanographic system dominated by a current regime which includes the Gulf Stream and Western Boundary Undercurrent, and by a greater diversity of substrata.

South Atlantic Shelf: The south Atlantic continental shelf area can be divided into five types of habitat: coastal, open shelf, live-bottom, shelf-edge, and upper continental slope. Each of these types has its own distinctive characteristics and species assemblages.

The coastal habitat has a smooth sandy-mud bottom and is usually shallower than 20 m (66 ft). The open shelf habitat is found at depths approximately between 20 and 55 meters (66 and 180 ft) and has a smooth, sandy substrate. This habitat predominates between the occasional live-bottom areas on the outer shelf. Typically, these are areas of relatively low productivity.

Live-bottom habitats, although sporadically distributed, are areas of high productivity and are usually found in water depths of approximately 20 to 55 m (66 to 180 ft). In shallower water, live-bottom areas are usually dynamic because water currents can transport the surface sand layer and cover existing communities or expose new hard bottoms for colonization. The deeper water live-bottom areas tend to be more stable. Thus, the complexity and average vertical relief of these live-bottom areas typically increase seaward. The exposed hard substrate in these areas has allowed colonization by many attached species, such as soft corals, and provides three dimensional habitat for many species, some of which are prey for billfish. These live-bottom areas provide habitat for the warm water snapper-grouper assemblage of fishes. In addition to these live-bottom communities, extensive banks of coral occur on the Blake Plateau at depths between 650 and 850 m (~2,100-2,800 ft). Along the shelf-edge water depths average between 40 and 100 m (130-325 ft). The bottom topography varies from smooth mud to areas of high relief with associated corals and sponges. The lowershelf habitat has smooth mud bottoms in water depths between 100 and 200 m (~330 and 660 ft).

The shelf-edge habitat may range in water depth between 40 and 100 m (131 and 328 ft). The bottom topography varies from smooth sand to mud to areas of high relief with associated corals and sponges. The fish species found in this area include parrotfish (Scaridae) and the deepwater species of the snapper-grouper assemblage. Many juveniles of certain species of fishes are found in *Sargassum* (pelagic brown algae)overlying this habitat, but the fate of these juveniles is unknown.

The final category in the south Atlantic, the upper continental slope habitat, has smooth mud bottoms in water depths of 100 to 200 m (328 to 656 ft). Many of the species in this zone are representatives of cold water northern species exhibiting tropical submergence (i.e., being located in deeper, cooler water as latitude decreases).

This pattern - hard and soft bottom habitats interspersed - also occurs in the southern part of the Atlantic shelf (Miami to the Dry Tortugas). The Florida shelf is a limestone platform which is exposed in some areas and covered with quartz and carbonate sands in others. Off-shore hard bottom habitats usually consist of rock covered by a thin, mobile, sand veneer. These areas are usually colonized by a diverse biota of tropical and temperate species, including macroalgae, stony corals, soft corals, sponges, and bivalves. Overall, about 30 percent of the southwest Florida shelf consists of live bottom areas. In addition, this area contains most of the true coral reefs, and their associated fauna, found in North America. The coral reef areas are highly diverse habitats with complex three-dimensional space and relatively high biological productivity. In order to protect a diverse, fragile coral habitat off the coast of central Florida, the Oculina Bank has been designated a Habitat of Particular Concern (HAPC) by the South Atlantic Fishery Management Council. Within the HAPC, fishing with bottom longline, bottom trawl, dredge, pot, or trap, and also vessel anchoring, are prohibited, primarily to protect the delicately branching coral *Oculina varicosa* (SAFMC, 1998).

A topographic irregularity southeast of Charleston, SC, known as the Charleston Bump, is an area of productive sea floor which rises abruptly from 700 m (2,300 ft.) to 300 m (980 ft.) within a distance of about 20 km, and at an angle which is approximately transverse to both the general isobath pattern and the Gulf Stream currents. The Charleston Gyre is a persistent oceanographic feature that forms in the lee of the Charleston Bump. It is a location in which larval swordfish have been commonly found and may serve as nursery habitat for other billfish as well.

Deepwater banks occur predominantly beyond the outer edge of the continental shelf on the continental slope. Although their distribution is still being delineated, these structures have been identified in the western south Atlantic region, especially within Bahamian national waters, and have been reported in the Straits of Florida off Little Bahama Bank. Although most of them are outside U.S. waters, some do occur near the outer edge of the EEZ. The banks are composed of lithified sandy carbonate sediments supporting a regionally diverse array of benthic fauna, with ahermatypic branching corals forming most of the structure and habitats.

Physical Oceanography (Water Movements and Marine Habitats): (Material in this section is largely a summary of information found in MMS, 1992; 1996. Original sources of information are referenced in those documents.)

The shelf area of the Mid-Atlantic Bight averages about 100 km (~60 mi) in width, reaching a maximum of 150 km (~90 mi) near Georges Bank and a minimum of 50 km (~30 mi) offshore Cape Hatteras. The mean current flow is alongshelf and to the southwest, interspersed with localized areas where outflow from major estuaries (e.g., Connecticut River, Lower New York Bay, Delaware Bay, and Chesapeake Bay) interrupts the flow field. Current speeds are strongest at the narrowest part of the shelf where wind-driven current variability is highest. The slope area is influenced by the presence of the western Slope Sea Gyre, which is present 85 percent of the time, with a relatively strong net southeastward flow along the New Jersey coast.

In the high northern latitudes, North Atlantic Deep Water (NADW) flows southward out of the Norwegian Sea and into the Labrador Sea, forming the Deep Western Boundary Current (DWBC) (also known as the Western Boundary Undercurrent). After taking a counterclockwise course through the Labrador Sea, the DWBC flows around the Grand Banks of Newfoundland and then follows the topography of the U.S. Atlantic slope. It passes under the Gulf Stream near Cape Hatteras and continues into the South Atlantic. Meanders of the DWBC core account for variations in velocity and volume transport, according to measurements in the Blake Plateau region.

The continental shelf in the South Atlantic Bight varies in width from 50 km (32 mi) off Cape Canaveral, FL to a maximum of 120 km (75 mi) off Savannah, GA and a minimum of 30 km (19 mi) off Cape Hatteras. The shelf can be divided into three cross-shelf zones. Waters on the inner shelf (0 to 20 m [0 to 66 ft]) interact extensively with rivers, coastal sounds, and estuaries. This interaction tends to form a band of low-salinity, stratified water near the coast that responds quickly to local wind-forcing and seasonal atmospheric changes. Mid-shelf (20 to 40 m [66 to 130 ft]) current flow is strongly influenced by local wind events with frequencies of 2 days to 2 weeks. In this region, vertically well mixed conditions in the fall and winter contrast with vertically stratified conditions in the spring and summer. Gulf Stream frontal disturbances (e.g., meanders and cyclonic cold core rings) that occur on time scales of 2 days to 2 weeks dominate currents on the outer shelf (40 to 60 m [132 to 197 ft]).

The Gulf Stream produces periodic meanders, filaments, and warm and cold core rings that significantly affect the physical oceanography of the continental shelf and slope. This western boundary current has its origins in the tropical Atlantic Ocean (i.e., the Caribbean Sea). The Gulf Stream system is made up of the Yucatan Current that enters the Gulf of Mexico through the Yucatan Straits; the Loop Current, which is the Yucatan Current after it separates from Campeche Bank and penetrates the Gulf of Mexico in a clockwise flowing loop; the Florida Current, as it travels through the Straits of Florida and along the continental slope into the South Atlantic Bight; and the Antilles Current as it follows the continental slope (Bahamian Bank) northeast to Cape Hatteras. From Cape Hatteras it leaves the slope environment and flows into the deeper waters of the Atlantic Ocean.

The flow of the Gulf Stream as it leaves the Straits of Florida is jet-like with maximum speeds at the surface that are usually about 200 cm/s. During strong events, maximum current speeds greater than 250cm/s have been recorded offshore Cape Hatteras. The width of the Gulf Stream at the ocean surface ranges from 80 to 100 km (50 to 63 mi) and extends to depths of between 800 and 1,200 m (2624-3937 ft).

Meandering events of the Gulf Stream are caused by atmospheric forcing or bathymetric features (e.g., the Charleston Bump). Meanders are lateral oscillations of the mean current stream (flow field) produced by migrating waves. They may affect the location of the Gulf Stream's western boundary and have amplitudes (east-west displacement) of up to 25 km (15.5 mi) off the coast of Florida and Georgia. However, north of the Charleston Bump, the amplitude may increase to about 100 km (63 mi). Meanders occur periodically in the 2- to 15-day range.

As a meander passes, the Gulf Stream boundary oscillates sequentially onshore (crest) and offshore (trough). A meander can cause the Gulf Stream to shift slightly shoreward or well offshore into deeper waters. The Gulf Stream behaves in two distinct meander modes (small and large), with the size of the meanders decreasing as they move northward along the coast. During the large meander mode the Gulf Stream front is seaward of the shelf break, with its meanders having large amplitudes. Additionally, frontal eddies and accompanying warm-water filaments are larger and closer to shore. During the small meander mode the Gulf Stream front is at the shelf break. Frontal eddies and warm-water filaments associated with small amplitude meanders are smaller and farther from shore. Since billfish tend to follow the edge of the Gulf Stream, their distance from shore can be greatly influenced by the patterns of meanders and eddies.

Meanders have definite circulation patterns and conditions superimposed on the statistical mean (average) condition. As a meander trough migrates in the direction of the Gulf Stream's flow, it upwells cool nutrient-rich water, which at times may move onto the shelf and may evolve into an eddy. These boundary features move south-southwest. As warm-water filaments, they transfer momentum, mass, heat, and nutrients to the waters of the shelf break.

Gulf Stream filaments are mesoscale events which occur regularly offshore the southeastern United States. The filament is a tongue of water extending from the Gulf Stream pointing to the south. These form when meanders cause the extrusion of a warm-surface filament of Gulf

Stream water onto the outer shelf. The cul-de-sac formed by this extrusion contains a cold core that consists of a mix of outer-shelf water and nutrient-rich water. This water mix is a result of upwelling as the filament/meander passes along the slope. The period from genesis to decay is typically about 2 to 3 weeks.

The Charleston Gyre is a permanent oceanographic feature of the South Atlantic Bight, caused by the interaction of rapidly moving Gulf Stream waters with the topographically irregular Charleston Bump. The gyre produces an upwelling of nutrients, which contributes significantly to primary and secondary productivity of the Bight, and is thus important to some ichthyoplankton, including swordfish larvae (Govoni *et al.*, in prep). The degree of upwelling varies with the seasonal position and velocity of the Gulf Stream currents.

In the warm waters between the western edge of the Florida Current/Gulf Stream and 20° N and 40° N latitude, pelagic brown algae, *Sargassum natans* and *S. fluitans*, form a dynamic structural habitat. The greatest concentrations are found within the North Atlantic Central Gyre in the Sargasso Sea. Large quantities of *Sargassum* frequently occur on the continental shelf off the southeastern United States. Depending on prevailing surface currents, this material may remain on the shelf for extended periods, be entrained into the Gulf Stream, or be cast ashore. During calm conditions, *Sargassum* may form irregular mats or simply be scattered in small clumps. Oceanographic features such as internal waves and convergence zones along fronts aggregate the algae along with other flotsam into long linear or meandering rows collectively termed “windrows”.

Pelagic *Sargassum* supports a diverse assemblage of marine organisms including fungi, micro- and macro-epiphytes, sea turtles, numerous marine birds, at least 145 species of invertebrates, and over 100 species of fishes. The fishes associated with pelagic *Sargassum* include juveniles as well as adults, including large pelagic adult fishes. Billfishes are among the fishes that can be found associated with *Sargassum*. The *Sargassum* community, consisting of the floating *Sargassum* (associated with other algae, sessile and free-moving invertebrates, and finfish) is important to some epipelagic predators such as wahoo and dolphin. The *Sargassum* community provides food and shelter from predation for juvenile and adult fishes, and may have other functions such as habitat for fish eggs and larvae.

Offshore water quality in the Atlantic is controlled by oceanic circulation which, in the mid-Atlantic, is dominated by the Gulf Stream and by oceanic gyres. A shoreward, tidal and wind-driven circulation dominates as the primary means of pollutant transport between estuaries and the nearshore. Water quality in nearshore water masses adjacent to estuarine plumes and in water masses within estuaries is also influenced by density-driven circulation. Suspended sediment concentration can also be used as an indication of water quality. For the Atlantic coastal areas, suspended sediment concentration varies with respect to depth and distance from shore, the variability being greatest in the mid-Atlantic and south Atlantic. Resuspended bottom sediment is the principal source of suspended sediments in offshore waters.

Coastal Habitats: (Material in this section is largely a summary of information found in MMS, 1992; 1996. Original sources of information are referenced in those documents.)

Billfish are known to range offshore as far north as Georges Bank. Although they move primarily throughout open-ocean waters, two species, the white marlin and the sailfish can be found inshore. Sailfish are also known to move inshore to spawn off the east coast of Florida and in the Florida Keys. Coastal habitats that might be utilized by sailfish and other billfish are described in this section. Those areas that are known spawning grounds, or areas of billfish aggregation for feeding or other reasons, are considered to be EFH for those species. It should be noted that characteristics of coastal and offshore habitats may be affected by activities and conditions occurring outside of those areas (farther up-current) due to water flow or current patterns that may transport materials that could cause negative impacts.

A great diversity of shoreline types is found along the Atlantic coast. Much of the ocean frontage along Cape Cod and from Long Island to southern Florida consists of sandy beach-dunes and/or barrier beach areas. These barriers are separated in the north by broad estuaries and in the south by narrow, shallow lagoons. At the southern tip of Florida and along the Florida Keys swamps and mangroves are the dominant shoreline features. Mudflats exist along the shores of many of the bays and sounds, the most extensive found along the shores of Delaware and Chesapeake Bays and along the coast of Georgia. In addition, there are localized sections of dense shoreline development.

Beaches are particularly important for providing protection from storms, high tides, and wave action for the lagoons, sounds, wetlands, and low ground located landward of them. Natural dune areas found landward of sandy beaches often support seabirds, shorebirds, waterfowl, and a dune grass or shrub community. The ecologically fragile dune grass or shrub communities are important for maintaining beach and dune stability and are particularly intolerant of pollution or beach development. Mudflats, swamps, and mangroves occur in areas of low wave energy. These areas tend to act as sediment sinks, trapping nutrients that support a variety of plants, fish, birds, and mammals; they also trap and sequester pollutants.

The coastal ocean is a shallow, nutrient-rich, and productive environment. Longshore currents transport sediments (and nutrients) parallel to the typically north-south running shoreline and are a primary cause of the elongate barrier islands and narrow inlets common in this region. The numerous inlets and other passageways for exchange between the estuarine and oceanic waters provide an important conduit between systems for a diverse suite of living marine resources, many of which spend significant portions of their lives in either medium, or require a specific habitat type for growth and development during a specific life stage. The opportunity for movement between two very different systems contributes greatly to the biological productivity and, thus, the commercial importance of the mid-Atlantic coast.

The coastal zone is generally highly energetic; as offshore swells and waves begin to "feel" the bottom, crest, and break at the beach face. Storm energy is often concentrated in this zone as waves generated far offshore finally release their large amounts of latent power. This energy is often converted to strong currents which can carry large sediment loads and can erode shorelines and destroy man-made structures rapidly. Without hard structure for attachment, as is common in the mid-Atlantic, many sessile organisms cannot live in this environment. However, a number of attached animals find suitable substrate on man-made objects such as pilings and revetments, and many benthic filter-feeding organisms thrive in the rapid transfer of nutrients.

Wetland vegetation provides stability to coastal habitats by preventing the erosion of sediments and by absorbing the energy of storms. The dominant salt marsh vegetation along much of the Atlantic coast includes the cordgrasses (*Spartina* sp.), salt grass (*Distichlis spicata*), needle rushes (*Juncus roemerianus*), and other salt tolerant species. Because of the unique adaptations necessary for plants to survive in salt water environments, species diversity is much lower than in freshwater environments.

4.2.2 Gulf of Mexico

The Gulf of Mexico supports a great diversity of fish resources that are related to variable ecological factors, such as salinity, primary productivity, bottom type, etc. These factors differ widely across the Gulf of Mexico and between inshore and offshore waters. Characteristic fish resources are not randomly distributed; high densities of fish resources are associated with particular habitat types (e.g., east Mississippi Delta area, Florida Big Bend seagrass beds, Florida Middle Grounds, mid-outer shelf, and the De Soto Canyon area). The highest values of surface primary production are found in the upwelling area north of the Yucatan Channel and in the De Soto Canyon region. In terms of general biological productivity, the western Gulf is considered more productive in the oceanic region than is the eastern Gulf. Productivity of billfish resources varies between the east and west Gulf, depending on the influence of the Loop Current.

Continental Shelf/Slope Features: (Material in this section is largely a summary of information in MMS, 1992; 1996. Original sources of information are referenced in those documents.)

The Gulf of Mexico is a semi-enclosed, subtropical sea with a surface area of approximately 1.6 million km^2. The main physiographic regions of the Gulf basin are the continental shelf (including the Campeche, Mexican, and U.S. shelves), continental slopes and associated canyons, the Yucatan and Florida Straits, and the abyssal plains. The U.S. continental shelf is narrowest, at only 16 km (9.9 miles) wide, off the Mississippi River. Evidence suggests that the river outflow effectively splits the shelf into the Texas-Louisiana western province and the Mississippi-Alabama-Florida eastern province. The continental shelf width varies significantly from about 350 km (217 mi) offshore west Florida, 156 km (97 mi) off Galveston, Texas, decreasing to 88 km (55 mi) off Port Isabel near the Mexican border. The depth of the central abyss ranges to 4,000 m (13,000 ft). The Gulf is unique because it has two entrances: the Yucatan Strait and the Straits of Florida. The Gulf's general circulation is dominated by the Loop Current and its associated eddies. The Loop current is caused by differences between the sill depths of the two straits. Coastal and shelf circulation, on the other hand, is driven by several forcing mechanisms: wind stress, freshwater input, buoyancy and mass fluxes, and transfer of momentum and energy through the seaward boundary.

The physiographic provinces in the Gulf of Mexico--shelf, slope, rise, and abyssal plain--reflect the underlying geology. In the Gulf, the continental shelf extends seaward from the shoreline to about the 200 m water depth and is characterized by a gentle slope of less than one degree. The continental slope extends from the shelf edge to the continental rise, usually at about the 2,000 m (6,500 ft) water depth. The topography of the slope in the Gulf is uneven and is broken by canyons, troughs, and escarpments. The gradient on the slope is characteristically 1-6 degrees, but may exceed 20 degrees in some places, particularly along escarpments. The continental rise is the apron of sediment accumulated at the base of the slope. The incline is gentle with slopes of less than one degree. The abyssal plain is the basin floor at the base of the continental rise.

Texas/Louisiana Shelf Features: The shelf and shelf edge of the central and western Gulf are characterized by topographic features that are inhabited by hard-bottom benthic communities. The habitats created by the topographic features are important in several respects: they support hard-bottom communities of high biomass, high diversity, and high numbers of plant and animal species; they support, as shelter and/or food, large numbers of recreational and commercially important fishes; they are unique to the extent that they are small, isolated areas within vast areas of much lower diversity; they are relatively pristine areas (especially the East and West Flower Garden Banks); and they have an aesthetically attractive intrinsic value. Benthic organisms (primarily corals) that contribute to the relief of these features are mainly limited by temperature and light. Although corals will grow or survive under low light conditions, they do best while submerged in clear, nutrient-poor waters. Light penetration in the Gulf is limited by several factors including depth and events of prolonged turbidity. Hard substrate favorable to colonization by coral communities in the northern Gulf is found on outer shelf, high relief features.

Because midshelf banks experience less light penetration and colder temperatures, the biota differs significantly from outer shelf banks. Instead of the high diversity coral reef-building zone found at the Flower Gardens (outer shelf), the midshelf banks tend to be dominated by zones of minor reef building activity, e.g., Sonnier Bank, Stetson Bank, and Claypile Bank. Claypile Bank, with only 10 m of relief, is considered a low-relief bank and is often enveloped by the nepheloid layer. Thus, the level of biological community development (the Millepora-sponge community) is lowest at Claypile Bank. Two other midshelf banks, 32 Fathom Bank and Coffee Lump, have reliefs less than 10 m and are also considered to be low-relief banks. Geyer Bank, which crests at 37 m (within the depth that the high-diversity coral reef zone would be expected), does not contain a coral reef, and only minor reef building has occurred.

The south Texas banks are geologically distinct from the shelf edge banks. Several of the south Texas banks are low-relief banks, have few hard substrate outcrops, exhibit a reduced biota, and have a thicker sediment cover than the other banks. Sebree Bank is a low-profile feature located in 36.5 m (120 ft) of water. The highest area of the bank is about 31 m (102 ft) deep. The bank appears to be composed of large boulders mostly veneered by fine sediments. The low relief of the bank and the fine sediments covering it indicate that Sebree Bank frequently exists in turbid conditions, and the biota of the bank appears sparse due to these conditions. The bank attracts abundant nektonic species that utilize the overlying water column.

Eastern Gulf Shelf Features: Although the Gulf off Florida does not contain any of the topographic features common to the offshore areas of Texas and Louisiana, Florida offshore waters do contain several habitats of particular note which can be characterized as live-bottom.

The "pinnacle trend" can be found in the waters south-southwest of Mobile Bay between 67 and 110 m (220 and 360 ft). The pinnacles appear to be carbonate reef structures in an intermediate stage between growth and fossilization. These features may have been built during periods of lower sea level and during the rise in sea level following the most recent ice age. The hard structure of the pinnacles provides a surprising amount of surface area for the growth of sessile invertebrates and attracts large numbers of fishes. The pinnacles are found at the outer edge of the Mississippi/Alabama shelf between the Mississippi River and the De Soto Canyon. The bases of the pinnacles rise from the sea floor between 50 and 100 m, with vertical relief of 20 m. These pinnacles may provide structural habitat for a variety of pelagic fishes and their prey.

The northwest Florida shelf is dominated by sand-bottom assemblages with low-relief, low-diversity communities widely interspersed with carbonate outcroppings. These outcroppings occasionally serve as attractors for hard-bottom biota and large aggregations of small fishes.

Live bottoms are regions of high productivity characterized by a firm substrate supporting a high diversity of epibiota. These communities are scattered across the west Florida shelf in shallow waters with depth zonation apparent, and within restricted regions off Louisiana, Mississippi, and Alabama. The density of the epibiotal communities varies from sparse to 100 percent coverage of the bottom and largely depends on bottom type, current regimes, suspended sediments, habitat availability, and anthropogenic perturbations. Sessile epibiota include seagrasses, algae, sponges, anemones, encrusting bryozoans, and associated communities. For purposes of this document, live bottoms also include rocky formations with rough, broken, or smooth topography.

The Florida Middle Ground is probably the best known and most biologically developed of the eastern Gulf live bottoms, with extensive habitation by hermatypic (reef building) corals and related communities. This area is 160 km (99 mi) west-northwest of Tampa and has been designated as a Habitat Area of Particular Concern (HAPC) by the Gulf of Mexico Fishery Management Council (50 CFR 638). Bottom longlines, traps and pots, and bottom trawls are prohibited within the HAPC. The taking of any coral is prohibited except as authorized by permit from NMFS.

The Florida Middle Ground represents the northernmost extent of coral reefs and their associated assemblages in the eastern Gulf. The Middle Ground is similar to the Flower Garden Banks off Texas (typical Caribbean reef communities), although having a reduced number of species present, probably because it is nearer to the northern limit of viable existence for these types of coral communities. In the Caribbean, reefs may grow as deep as 80 m (260 ft), while in the Gulf they seem to be limited to a depth of about 40 m (130 ft). The Middle Ground reefs rise essentially from a depth of 35 m (115 ft), with the shallowest portions about 25 m (80 ft) deep. The Florida Middle Ground supports numerous Caribbean fishes, corals, and other invertebrate species. This is probably due to the intrusion of the Loop Current, short periods of low temperatures, and high biological productivity.

The southwest Florida shelf between 10 and 200 m (33-660 ft) in depth has been characterized as having several biological assemblages that are associated with particular substrates and depths. Although depth is probably not the decisive factor in determining the distribution of the biotic assemblages, three major biotic depth zones are evident: there appears to be an innershelf zone between 10 and 60 m (33-197 ft) water depths; a transitional zone between 60 and 90 m (197-297 ft); and an outer-shelf zone from 90 to 200 m (297-660 ft). A brief description of each assemblage can be found in the Gulf of Mexico Council's EFH amendment (GMFMC, 1998).

The Florida Keys comprise an important shallow water, tropical, coral reef ecosystem that is unique on the continental shelf of North America. The coral reefs of the Keys are vital to the economy of Florida. Commercial and recreational fishing, as well as non-consumptive uses such as boating, scuba diving, snorkeling, and educational and natural history activities, are economically important. The Florida reef tract is the only shallow water tropical coral reef ecosystem found on the continental shelf of North America. The Florida Keys archipelago, extending from Soldier Key to the Dry Tortugas, exhibits a diverse array of hard-grounds, patch reefs, and bank reefs from nearshore to 13 km (8 mi) offshore.

Patch reefs are the principal reef form between Elliott Key and Key Largo, where approximately 5,000 patch reefs are found. These reefs typically occur in water depths of about 2 to 9 m (6.6-30 ft). Bank reefs occur 7.4 to 13 km seaward of the Keys, paralleling the coast, with most occurring off Key Largo and from Big Pine Key to Key West, where major islands protect the reefs from the detrimental influence of Florida Bay waters. A reef flat is located on the inshore side of bank reefs. The deepest portions of the Florida bank reefs are in 37 to 40 m (121-132 ft) depths and occur as isolated outcrops surrounded by sediments. The Dry Tortugas are composed of islands, shoals, and reefs located about 117 km (73 mi)west of Key West.

Physical Oceanography (Water Movements and Marine Habitats): (Material in this section is largely a summary of information in MMS, 1992; 1996. Original sources of information are referenced in those documents.)

The Gulf receives large amounts of freshwater runoff from the Mississippi River as well as from a host of other drainage systems. This runoff mixes with the surface water of the Gulf, making the nearshore water chemistry quite different from that of the open ocean. Sea surface salinities along the northern Gulf vary seasonally. During months of low freshwater input, salinities near the coastline range between 29 to 32 parts per thousand (ppt). High freshwater input conditions during the spring and summer months result in strong horizontal gradients and inner shelf salinities less than 20 ppt. The mixed layer in the open Gulf, from the surface to a depth of approximately 100 to 150 m (330 to 495 ft), is characterized by salinities between 36.0 and 36.5 ppt.

Sharp discontinuities of temperature and/or salinity at the sea surface, such as the Loop Current front or fronts associated with eddies or river plumes, are dynamic features that may act to concentrate buoyant material such as spilled oil, detritus, plankton or eggs and larvae. These materials are transported, not by the front's movements or motion across the front, but mainly by lateral movement along the front. In addition to open ocean fronts, a coastal front, which separates turbid, lower salinity water from the open-shelf regime, is probably a permanent feature of the northern Gulf shelf. This front lies about 30 to 50 km offshore. In the Gulf these fronts are the most commonly utilized habitat of the pelagic billfish species.

The Loop Current is a highly variable current entering the Gulf through the Yucatan Straits and exiting through the Straits of Florida (as a component of the Gulf Stream) after tracing an arc that may intrude as far north as the Mississippi-Alabama shelf. This current has been detected down to about 1,000 m below the surface. Below that level there is evidence of a countercurrent. The "location" of the Loop Current is definable only in statistical terms, due to its great variability. Location probabilities during March, the month of greatest apparent intrusion, range from 100 percent in the core location at 25° N, down to small probabilities (10 percent) near midshelf. Analysis has indicated an average northern intrusion to 26.6° N, within a wide envelope.

When the Loop Current extends into or near shelf areas, instabilities, such as eddies, may develop that can push warm water onto the shelf or entrain cold water from the shelf. These eddies consist of warm water rotating in a clockwise fashion. Major Loop Current eddies have diameters on the order of 300 to 400 km (186-249 mi) and may extend to a depth of about 1,000 meters. Once these eddies are free from the Loop Current, they travel into the western Gulf along various paths to a region between 25° N to 28° N and 93° W to 96° W. As eddies travel westward, a decrease in size occurs due to mixing with resident waters and friction with the slope and shelf bottoms. The life of an individual eddy, until its eventual assimilation by regional circulation in the western Gulf, is about one year. Along the Louisiana/Texas slope, eddies are frequently observed to affect local current patterns, hydrographic properties, and possibly the biota of fixed oil and gas platforms or hard bottoms. Once an eddy is shed, the Loop Current undergoes major dimensional adjustments and reorganizations.

Small anticyclonic (clockwise) eddies are also generated by the Loop Current. They have diameters on the order of 100 km (62 mi), and the few data available indicate a shallow vertical extent (ca. 200 m or 660 ft). These smaller eddies have a tendency to move westward along the Louisiana/Texas slope. Also, cyclonic (counterclockwise) eddies associated with the larger scale eddy process have been observed in the eastern Gulf and the Louisiana/Texas slope. Their origin and role in the overall circulation are presently not well understood. A major eddy seems to be resident in the southwestern Gulf; however, recent evidence points toward a more complex and less homogeneous structure.

Shelf circulation is complicated because of the large number of forces and their variable seasonality. A northward current driven by prevailing winds and the semi-permanent anticyclonic eddy exists offshore south Texas. A strong east-northeasterly current along the remaining Texas and Louisiana slope has been explained partly by the effects of the semi-permanent anticyclonic eddy and a partner cyclonic eddy. West of Cameron, LA (93° W), current measurements clearly show a strong response of the coastal current to the winds, whereby a large-scale anticyclonic gyre is set up. The inshore limb of this gyre is the westward or southwestward (downcoast) component that prevails along much of the coast, except in July-August. Because the coast is concave the shoreward prevailing wind results in a convergence of coastal currents. A prevailing countercurrent toward the northeast along the shelf edge constitutes the outer limb of the gyre. The convergence at the southwestern end of the gyre migrates seasonally with the direction of the prevailing wind, ranging from a point south of the Rio Grande in the fall to the Cameron area by July. The gyre is normally absent in July but reappears in August/September when a downcoast wind component develops.

The Mississippi/Alabama shelf circulation pattern is not well understood at present although there appears to be divergent flow near the delta region. Offshore Panama City, FL the prevailing flow is eastward, but reversals occur at the time of maximum westward wind components. Offshore Mobile, AL, currents are eastward on the average, and flow reversals coincide with eastward winds. Most current reversals occur during the summer or during Loop Current intrusion events. The inner shelf general circulation is a two-season event. During the winter the water column is homogeneous and surface circulation is mainly alongshore and westward with the cross-shelf component weaker and directed onshore. During spring-summer conditions, the surface flow is mostly eastward. Under winds with easterly components, the water tends to flow shoreward and accumulate against the shoreline, creating a pressure gradient that drives bottom water alongshore in the direction of the winds. However, Loop Current intrusions, when present, will completely dominate the shelf circulation.

The west Florida shelf circulation is dominated by tides, winds, eddy-like perturbations, and the Loop Current. The flow consists of three regimes: the outer shelf, the mid-shelf, and the coastal boundary layer. Also, the Loop Current and eddy-like perturbations are stronger in this region. During Loop Current intrusion events, upwelling of colder, nutrient-rich waters has been observed. In waters less than 30 m (98 ft) deep the wind-driven flow is mostly alongshore and parallel to the isobaths. A weak mean flow is directed southward in the surface layer. In the coastal boundary layer longshore currents driven by winds, tides, and density gradients predominate over the cross-shelf component. Common flow ranges from moderate to strong, and the tidal components are moderate. Longshore currents, due to winter northerlies, tropical storms, and hurricanes may range much higher, depending on local topography, fetch, and duration. Longshore currents consisting of tidal, wind-driven, and density-gradient components predominate over across-shelf components within a narrow band (10-20 km) close to the coast, referred to as the coastal boundary layer.

Sea-surface temperatures in the Gulf range from nearly constant throughout (isothermal) (29 to 30° C) in August to a sharp horizontal gradient in January, (from 25° C in the Loop Current core to 14-15° C along the northern shelves). Surface salinities along the northern Gulf are seasonal. During months of low freshwater input, salinities near the coastline range between 29 to 32 ppt. High freshwater inputs (spring-summer months) are characterized by strong horizontal salinity gradients and inner shelf values of less than 20 ppt. The vertical distribution of temperature reveals that in January the thermocline depth is about 30 to 61 m (98 to 200 ft) in the northeastern Gulf and 91 to107 m (298 to 350 ft) in the northwestern Gulf. In May, the thermocline depth is about 46 m (150 ft) throughout the entire Gulf.

Dissolved oxygen varies seasonally, with a slight lowering during the summer months. Very low oxygen levels (anoxia) have been found to occur in some areas of open Gulf bottom waters. A zone of hypoxia affecting up to 16,500 square kilometers of bottom waters during mid-summer on the inner continental shelf from the Mississippi River delta to the upper Texas coast has been identified, most likely the result of high summer temperatures combined with freshwater runoff carrying large nutrient loads from the Mississippi River.

4.2.3 U.S. Caribbean

The waters of the Caribbean region include the coastal waters surrounding the U.S. Virgin Islands and Puerto Rico. The marine habitats found within the region are the products of, and key factors, shaping local terrestrial, geological, and hydrological regimes. The territory of the U.S. Virgin Islands includes roughly 63 islands, the largest of which are St. Thomas (83 square kilometers or 32 square miles), St. John (52 square kilometers or 20 square miles), and St. Croix (207 square kilometers or 80 square miles). The commonwealth of Puerto Rico includes many islands, the largest of which is Puerto Rico. To the south lie numerous cays covered with sand, coral, and mangroves. To the west lie Mona, Monito, and Desecheo Islands. To the northeast lies the chain of islands called La Cordillera. To the southeast lies Vieques Island. All of these Caribbean islands, with the exception of St. Croix, are part of a volcanic chain of islands formed by the subduction of one tectonic plate beneath another. Tremendously diverse habitats (rocky shores, sandy beaches, mangroves, seagrasses, algal plains, and coral reefs) and the consistent light and temperature regimes characteristic of the tropics are conducive to high species diversity.

The waters of the Florida Keys and southeastern Florida are intrinsically linked with the waters of the Gulf of Mexico and the waters of the Caribbean to the west, south, and east, and to the waters of the South Atlantic Bight to the north. These waters represent a transition from insular to continental regimes and from tropical to temperate regimes. This zone, therefore, contains one of the richest floral and faunal complexes.

Insular Shelf Features: Puerto Rico and the U.S. Virgin Islands contain a wide variety of coastal marine habitats, including coral and rock reefs, seagrass beds, mangrove lagoons, sand and algal plains, soft bottom areas, and sandy beaches. These habitats are, however, very patchily distributed. Nearshore waters range from 0 to 20 m in depth, and outer shelf waters range from 20 to 30 m in depth, the depth of the shelf break. Along the north coast the insular shelf is very narrow (2 to 3 km wide), seas are generally rough, and few good harbors are present. The coast is a mixture of coral and rock reefs, and sandy beaches. The east coast has an extensive shelf that extends to the British Virgin Islands. Depth ranges from 18 to 30 m. Much of the bottom is sandy, commonly with algal and sponge communities. The southeast coast has a narrow shelf (8 km wide). About 25 km to the southeast is Grappler Bank, a small seamount with its summit at 70 m depth. The central south coast broadens slightly to 15 km and an extensive seagrass bed extends 9 km offshore to Caja de Muertos Island. Further westward the shelf narrows again to just 2 km before widening at the southwest corner to over 10 km. The entirety of the southern shelf is characterized by hard or sand-algal bottoms with emergent coral reefs, grassbeds, and shelf edge. Along the southern portion of the west coast the expanse of shelf continues to widen, reaching 25 km at its maximum. A broad expanse of the shelf is found between 14 and 27 m, where habitats are similar to those of the south coast. To the north, along the west coast, the shelf rapidly narrows to 2 to 3 km.

Physical Oceanography (Water Movements and Marine Habitats) Hydrologic patterns link the waters of the U.S. Caribbean with the Florida Keys and southeastern Florida. The marine waters of the U.S. Caribbean are primarily influenced by the waters of the westward flowing North Equatorial Current, the predominant hydrological driving force in the Caribbean region. It flows from east to west along the northern boundary of the Caribbean plateau and splits at the Lesser Antilles, flowing westward along the north coasts of the islands. North of the Mona Channel it splits, with one branch flowing north of Silver and Navidad Banks, past Turks and Caicos to form the Bahamas Current. The southern branch stays along the north coast of Hispañola about 30 km offshore. A small gyre has been documented off the northwest corner of Puerto Rico, resulting in an easterly flow nearshore in this area.

The north branch of the Caribbean Current flows west into the Caribbean Basin. It is located about 100 km south of the islands, but its position varies seasonally. During the winter it is found further to the south than in summer. Flow along the south coast of Puerto Rico is generally westerly, but this is offset by gyres formed between the Caribbean Current and the island. The Antilles Current flows to the west along the northern edge of the Bahamas Bank and links the waters of the Caribbean to those of southeastern Florida.

Several rivers, including the Amazon, the Orinoco, the Magdelana, and the Columbian, exert intermittent but important influence on the waters of the Caribbean Basin. The plume from the Orinoco River, which flows up the Lesser Antilles and along the Greater Antilles, for example, can carry with it high concentrations of suspended particles, unique chemical properties, and biota to near the south coast of Puerto Rico. The plume, therefore, can be responsible for events of high turbidity and algal blooms that usually occur in the Caribbean Basin in October.

Coastal surface water temperatures remain fairly constant throughout the year and average between 26° and 30° C. The salinity of coastal waters is purely oceanic and so is usually around 36 ppt. However, in enclosed or semi-enclosed embayments salinity may vary widely, depending on fluvial and evaporational influences.

It is believed that no up-welling occurs in the waters of the U.S. Caribbean (except perhaps during storm events) and, since the waters are relatively stratified, they are severely nutrient-limited. In tropical waters nitrogen is the principal limiting nutrient.

Coastal Habitats (Material in this section is largely a summary of information in Appeldoorn and Meyers 1993. Original sources of information are referenced in that document.)

Billfish are known to move close to shore off Puerto Rico and the Virgin Islands, although this is probably because of the narrow width of the insular shelf. Although the U.S. waters of the Caribbean are relatively nutrient poor and so have low rates of primary and secondary productivity, they display some of the greatest diversity of any part of the south Atlantic region. High and diverse concentrations of biota are found where habitat is abundant. Coral reefs, seagrass beds, and mangrove ecosystems are the most productive of the habitat types found in the Caribbean, but other areas such as soft-bottom lagoons, algal hard grounds, mud flats, salt ponds, sandy beaches, and rocky shores are also important in overall productivity. These diverse habitats allow for eclectic floral and faunal populations.

Offshore, between the seagrass beds and the coral reefs and in deeper waters, sandy bottoms and algal plains dominate. These areas may be sparsely or densely vegetated with a canopy of up to one meter of red and brown algae. Algal plains are not areas of active sand transport. These are algae-dominated sandy bottoms, often covered with carbonate nodules. They occur primarily in deep water (> 15 m or 50 ft) and account for roughly 70 percent of the area of the insular shelf of the U.S. Virgin Islands. Algal plains support a variety of organisms including algae, sponges, gorgonians, solitary corals, molluscs, fish, and worms and may serve as critical juvenile habitat for commercially important (and diminishing) species such as queen triggerfish and spiny lobsters.

Coral reefs and other coral communities are some of the most important ecological (and economic) coastal resources in the Caribbean. They act as barriers to storm waves and provide habitat for a wide variety of marine organisms, including most of the economically important species of fish and shellfish. They are the primary source for carbonate sand, and serve as the basis for much of the tourism. Coral communities are made by the build up of calcium carbonate produced by living animals, coral polyps, in symbiosis with a dinoflagellate, known as zooxanthellae. During summer and early fall, most of the coral building organisms are at or near the upper temperature limit for survival and so are living under natural conditions of stress. Further increase in local or global temperature could prove devastating.

4.3 Life History and Essential Fish Habitat Descriptions

4.3.1 Introduction

For highly mobile, pelagic species such as billfish, defining EFH offers unique challenges. Collectively, these species are widely dispersed throughout the world's oceans, and move frequently over great horizontal distances, commonly migrating vertically within the water column. [In the following accounts, these movements will only be referred to as migrations for those species for which there is evidence of seasonality or regularity.]

The NMFS regulatory interpretation of the 1996 Magnuson-Stevens Act (i.e., the EFH regulations) requires that NMFS and the regional fishery management councils use the best available scientific information to determine EFH for all managed species. As described in Section 4.1, an initial review of available literature and information was undertaken to assess habitat use and ecological roles of the species in the billfish fishery management unit. Published and unpublished scientific reports, fishery independent and fishery dependent data, and expert and anecdotal information were synthesized, after appropriate evaluation, for inclusion in this amendment, detailing the habitat use by the managed species. Habitats that satisfy the criteria in the Magnuson-Stevens Act and the EFH regulations have been identified and described as EFH.

Identifying EFH for billfish is challenging because they are primarily blue-water (i.e., open-ocean) species, although they also frequent neritic waters of the continental shelf, and sometimes enter coastal waters, as well - white marlin and sailfish enter coastal waters, particularly for spawning (sailfish). Their distributions are usually not correlated with the areas or features one commonly thinks of as fish habitat (e.g., seagrass beds or estuarine subtidal rocky bottoms) and for which one can describe parameters such as bottom sediment type or vegetative density. These fishes most often associate with physiographic structures in the water column (features including oceanic fronts, river plumes, current boundaries, shelf edges, sea mounts, and temperature discontinuities, and the interactions of these); it is these features that must be characterized as habitat for the pelagic life stages of these species. Distribution of juveniles, adults, and especially early life stages may be constrained by tolerance of temperature, salinity or oxygen levels. These physicochemical properties may be used to define the boundaries of essential habitat in a broad sense. However, even when these parameters and tolerances are well understood and can be used to define the limits of a habitat, the distribution of these characteristics is not fixed in space or time, but varies over seasons and years. Although the EFH regulations allow for inferring habitat between species with similar ecological niches, the basic lack of knowledge of the proximate factors that attract billfish to particular habitats precludes inference of EFH between these species at this time. By including a review of the ecological roles as predator and billfish prey, this amendment establishes a framework for using a broader ecosystem approach to evaluating habitat use and EFH requirements that will be pursued in future amendments.

The EFH regulations also require the identification of actions that may adversely affect EFH and conservation measures to mitigate these potential threats. In spite of the apparent distance of their prime habitats from shore, billfish are susceptible to adverse effects from inshore activities because their distributions are correlated with river plumes, current boundaries, canyons and convergence zones which either serve to transport or concentrate materials directly into offshore habitats. In addition, certain billfish (e.g., blue marlin) enter coastal waters to spawn. Thus, the wide distribution of billfish and their EFH requires that a broad approach to habitat protection be taken. Loss or degradation of these crucial habitats may result in concomitant declines in productivity. Threats to EFH from both fishing and non-fishing activities are treated in detail under Section 4.4.

Process Used for Identification of EFH for Billfish

There is evidence that certain areas, such as spawning grounds, serve important habitat functions for billfish, either throughout the year or seasonally. Although actual spawning has not been observed for many of these species, the presence of eggs and larvae is frequently used as a proxy for spawning areas. Therefore, the location of spawning grounds has only been defined in a very broad sense. It is not known which parameters, beyond some temperature boundaries, define these as appropriate spawning areas. Additionally, eggs and larvae of these species are some of the rarest collected, and the picture of spawning and distribution of eggs and larvae is far from complete. Larvae and juveniles have a rapid growth rate, and few specimens, especially of early juveniles, are ever collected. When larvae have been collected, their identification to species has proven to be very difficult and it must be assumed that many earlier identifications have been incorrect (W.J. Richards, per. comm.). In some cases even the identification of adults is problematic and therefore caution was used when interpreting data. It is clear that much more research is needed on spawning grounds, species identifications, and habitat requirements before areas of importance to billfish can be more clearly delineated.

Under the Magnuson-Stevens Act EFH includes areas necessary for feeding. Billfish may exhibit different feeding characteristics in different parts of their ranges. While researchers have identified relative proportions of prey in billfish diets, it appears that they are opportunistic feeders able to exploit a large diversity of fishes, cephalopods and crustaceans. This precludes using the distributions of major prey species as indicators of billfish EFH. Additional research into prey dynamics is necessary to gain a better understanding of the importance of prey species to billfish. It has been suggested that billfish associate with water column structures because they offer prime feeding opportunities; these structural habitats tend to coincide with areas of upwelling, convergence zones, and other hydrographic features. In addition, much of the information on the distribution of billfish suggests that the utilization of these feeding areas has a temporal or seasonal component that should be more fully explored and delineated in future research.

There is little additional information to help refine EFH for these species. Some species appear to be primarily distributed above the thermocline or between certain isotherms; these temperature limits may define the outer boundaries of EFH for those species. As indicated above, some species aggregate at frontal boundaries in the ocean, with floating objects (such as *Sargassum*), or at bottom features such as the continental shelf break, submarine canyons, and even shipwrecks. Occasionally, the aggregations form where a front or boundary lies above one of these bottom features. These aggregations are most likely associated with prime feeding grounds and, as such, these areas are identified as EFH.

As discussed in Section 4.2, *Sargassum* has been identified as important habitat for many fish species. Billfish have also been found associated with *Sargassum*, and are known to frequent various types of drift materials. However, the importance of *Sargassum* as habitat for billfish remains unclear, as the few scientific investigations conducted to-date have collected limited numbers of individuals. Further complicating the determination of *Sargassum*'s importance to billfish is that floating mats tend to aggregate along convergence zones and fronts, areas where billfish are known to gather even in the absence of *Sargassum*. Clearly, more investigations are needed to gain a better understanding of the role of *Sargassum* concerning billfish. At this time, however, when *Sargassum* is present in areas that have been designated EFH for billfish, it is also considered EFH, as it has been recognized to be an important biological component of those areas. Further discussion concerning *Sargassum* can be found in Section 4.4.

Based on the available data or scientific knowledge, EFH for Atlantic billfish has been identified for each species. Life history stages have been combined into logical ecological groupings indicative of habitat use:

- "**Spawning, eggs and larvae**" largely depend on spawning locations and water motion to control their distributions. Spawning locations are identified based on published accounts that identify concentrations of spawning activity or extrapolate probable locations upcurrent of egg and larval distributions.

- "**Juveniles and subadults**" are swimming stages that show increased mobility patterns and develop transient lifestyles. Some fish in this size class are taken by targeted fishing and as bycatch.

- "**Adults**" are fish that are sexually mature; the size criterion is "those fish greater than or equal to the size at first maturation of females." For billfish they are the bulk of the fishery because of the minimum size limit regulations.

The current EFH descriptions and delineations for billfish conform to the standards proposed by the NMFS regulations. Since the current status of the scientific knowledge of these species is such that habitat preferences are largely undefined or are difficult to determine, EFH is based on presence/absence and relative abundance data, as available. To the extent that environmental information is available, it has been included in the EFH descriptions. The most common factors included are temperature and salinity ranges, depths (isobaths), and association with particular water masses or currents. The textual accounts for each species serve as the legal description of EFH, and where environmental characterizations are known they have been included. Maps are provided as supplemental material to facilitate visualization of EFH locations. Shaded polygons marking the outer boundaries of EFH for each life stage have been drawn on the maps, based on analyses of the available data. Locations within the boundaries of EFH for a species' life stage that do not meet the added environmental factors provided (e.g., salinity or temperature) are not considered EFH.

The following life history accounts (Section 4.3.2) details what is known about each species' life history, distribution and ecological roles as they relate to habitat use. Current status of the fishery is included since it may have implications in the current or historic range of the species. "U.S. Fishery Status" is based on the most recent NMFS report to Congress, required under the Magnuson-Stevens Act, "Status of Fisheries of the United States," October 1998.

In general, the designations of EFH for billfish, as they currently stand, are a combination of life history information, expert opinion regarding the importance of certain areas, and presence/absence and relative abundance information from fishery independent and dependent sources. It should be noted that much of the work on the basic ecology of these fishes is not recent; most is from the 1980s or before. Without more basic research on life history, habitat use, behavior and distribution of all billfish life stages, defining EFH for these species will continue to be difficult.

Methodology for Identification of EFH for Billfish

Determining EFH for billfish presents special concerns that can be addressed in a number of ways. Preferentially, relevant habitat use information could be combined with habitat quality and quantity data and species abundance information to produce models of likely areas of habitat preference that could then be prioritized and protected. Alternatively, temporally variable environmental conditions that constrain habitat use (e.g., temperature extremes, physical features such as density fronts, etc) could be mapped and serve as limiting boundaries to exclude unavailable habitats. An ideal model might incorporate both methods; however, development of such analyses is time consuming and costly for species for which this data exist, and impossible for those species for which it is incomplete.

The inference of EFH based on species locational information, such as presence/absence and catch data, requires the identification of important caveats. Misinterpretation or misuse of such data may result in the protection of marginal habitats or the exclusion of very important habitats. In circumstances where questions of delineating EFH arose, the precautionary approach was employed; however, to minimize the potential misidentification of EFH, multiple data sets were evaluated. Criteria were developed to minimize concerns regarding the incorporation and analysis of both fisheries dependent and fisheries independent data sets. Chief among these concerns was the spatial and temporal extent of the studies that have generated the data. The accuracy of the data, especially in the identification of certain species and in the reporting of length of individual fish, was also considered. Comparisons between disparate data sets (and the lack of full corroboration between them) were performed cautiously and provide additional room for improvement in subsequent FMP amendments. Finally, given the congressional deadlines and geographic area involved, the analyses and EFH designations as they now stand are primarily limited by time and effort.

In order to proceed cautiously with our analyses, while still meeting the mandated deadline for this amendment, certain priorities of data gathering and presentation were identified. We constrained our efforts to large-scale data sets, with spatial coverage of a minimum of several states and preferentially of the entire North Atlantic and Caribbean, including areas beyond the U.S. EEZ. In addition, we favored data sets with a large temporal extent. In certain instances this was not possible, and a single year of observations were included. Many fisheries dependent data sets are limited temporally; however, we have been able to incorporate data from one long-term study that reaches into the 1940s.

To visually represent species presence/absence, the data were analyzed using a Geographic Information System (GIS). Once an overall range was established using multiple data sets, a refinement of our understanding of each species consisted of analyses within data sets of the location and characteristics of individual fish (e.g., length, sex, date of capture), where possible, and a comparison of areas of aggregation, either through a thorough analysis of absolute catch (numbers of fish caught) or a preponderance of locational data. In many cases these exercises were restricted by specific types of data (e.g., locational data for tagging-based data sets, or catch data for fishery reporting data sets); one observer program data set allowed for both types of analyses.

Noticeable areas of aggregations, as bounded by some easily identifiable geographic feature or description (e.g., bathymetry, distance from shore, etc), were delineated as EFH for each relevant species' life stages. Where expert opinion was available and data points were scarce, areas were defined as EFH based on our best interpretation of our life history accounts; this became especially important for spawning areas and eggs and larvae, since no data sets that met our criteria were available. EFH boundaries were digitized and processed into maps to supplement the text descriptions and tabular information provided in this amendment. Only those habitats that occur within the boundaries as they are interpreted through the text, maps and tables in conjunction are considered EFH. For example, within any given EFH boundary on a map, "essential" habitats occur; the boundary does not encompass all habitats within it as essential, unless the text and tables indicate so. In any case, where the text description of EFH and the map supporting that description conflict, the legal definition of EFH lies with the text and tables.

Data Sets Utilized to Assist the Delineation of Essential Fish Habitat

The primary source of data that satisfied our initial criteria for spatial and temporal coverage was the NMFS Southeast Fisheries Science Center (SEFSC) in Miami, FL. The SEFSC houses a long-term data set administered by The Billfish Foundation. Since the 1940s large pelagic species have been caught, tagged, released alive and recaptured to investigate the extent of their horizontal, sometimes transoceanic, movements. This data set provides presence/absence locational data of a tagged position as well as some length and sex information (often estimated). The primary utility of this data for EFH purposes is its long-term nature, which allows for an analysis of the historical range of a species. This "Release and Recapture" database also has the largest spatial extent of any of our databases. Primary limitations include a lack of confidence in species identifications for more difficult species, and the lack of accurate (measured) size data. These data are primarily the result of years of tagging by recreational fishermen, although commercial fishermen and academicians have contributed as well.

The commercial pelagic longline fleet is monitored from the SEFSC. This is done in two ways. Under one monitoring program fishing boat captains must keep a log of the fish they have caught by location, recording species, number of fish kept or discarded, and information on effort and gear. This information is reported to the NMFS SEFSC where the Pelagic Longline Logbook data base is maintained. We have queried this database for 1992 to 1997 for species in the billfish management unit. Considering the large amount of records maintained in this database, we have binned, or aggregated, the catch information into 0.5 degree cells based on latitude and longitude. This data set does not provide information on individual fish caught.

Under another monitoring program the same commercial pelagic longline fleet is monitored by the SEFSC through the Southeast Observer Program. This program places trained observers on board commercial fishing boats. The observers record information on location, numbers of fish caught per set, effort and gear as well as the characteristics of individual fish such as sex, length, weight, condition, etc. Realistically, this program represents a more accurate sub-sample of the Pelagic Longline Logbook. While it may be assumed that trained observers can and do make positive identifications and accurate measurements, these data cannot be solely relied upon. The primary limitations of this database are the lack of consistent coverage throughout the EEZ and a small number of records, especially for incidentally encountered species.

4.3.2 Species Accounts and Essential Fish Habitat

Blue Marlin *(Makaira nigricans)*

Distribution: Blue marlin inhabit the tropical and subtropical waters of the Atlantic, Pacific and Indian Oceans. Their geographic range is from 45° N to 35° S. In the Atlantic two seasonal concentrations occur: January to April in the southwest Atlantic from 5 to 30° S, and from June to October in the northwest Atlantic between 10° N and 35° N. May, November and December are transitional months (Rivas, L.R. *in* Shomura and Williams, 1975). This species is epipelagic and oceanic, generally found in blue water with a temperature range of 22 to 31° C. In the northern Gulf of Mexico fishermen tend to catch more blue marlin when white marlin catches are lowest and vice versa, this probably reflecting differences in habitat preferences rather than any interaction between the species. Blue marlin are generally solitary, and do not occur in schools or in coastal waters (Nakamura, 1985). It had been held that the North and South Atlantic contains two separate spawning populations, but recent evidence, including genetic data, suggests there is intermingling of the two groups. Consistent with SCRS recommendations, this amendment considers there to be a single stock of Atlantic blue marlin. Tag-recapture data from the northern Gulf of Mexico and the Bahamas suggest seasonal movements between the former in summer and the latter in winter, and also two-way movements between the Caribbean Islands and Venezuela and the Bahamas, and at least one-way movements from St. Thomas to west Africa. Blue marlin from this study traveled up to 7,000 km (4,350 mi) and have remained at-large (i.e., from tagging until recapture) for up to eight years (Witzell and Scott, 1990).

As part of the Cooperative Tagging Center (CTC) program, a total of 21,547 blue marlin have been tagged and released over the last 43 years, with the recapture of 147 tagged fish reported (0.68 percent of all releases) over the 23-year collaborative tagging effort (Jones *et al.*, 1997). Most tagging activity has taken place off the U.S. east coast, Gulf of Mexico and Caribbean, generally during the months of July through September. The majority of blue marlin were recaptured in the general area of their release, traveling an average distance of 488 nm. Some individuals have exhibited extended movement patterns, and strong seasonal patterns of movement of individuals between the United States and Venezuela are evident (SCRS, 1997). A blue marlin released off Delaware and recovered off the island of Mauritius in the Indian Ocean represents the only documented inter-ocean movement of a highly migratory species in the history of the CTC. The minimum straight line distance traveled for this fish was 9,100 nm in 1,108 days-at-large (roughly three years). Other extensive movements include trans-equatorial movements and trans-Atlantic migrations (5.4 percent of CTC recaptures; Jones *et al.*, 1997).

Predator-prey relationships: Blue marlin feed near the surface but also are known to feed in deeper waters than the other istiophorids. They feed primarily on tuna-like fishes and squid, and on a wide size range of other organisms, from 38 mm postlarval surgeonfish to 50 lb. bigeye tuna. Stomach contents have also included deep-sea fishes such as chiasmodontids. Other important prey species vary by location and include dolphinfishes, especially bullet tuna (*Auxis* sp.) around the Bahamas, Puerto Rico, and Jamaica, and dolphinfishes and scombrids in the Gulf of Mexico. Octopods are also prey items (Nakamura, 1985; Davies and Bortone, 1976; Rivas, 1975). Predators of blue marlin are relatively unknown. Sharks will attack hooked billfish, but it is not known if they attack free-swimming healthy individuals.

Reproduction and Early Life History: Although recent evidence indicates mixing between the two geographic areas, there are probably two separate spawning "events" (or populations), one in the north Atlantic with spawning from July to September (July to October according to de Sylva and Breder, 1997; May to November, according to Prince *et al.*, 1991) and one in the south Atlantic from February to March. May and June are the peak spawning months for fish off Florida and the Bahamas, and there is a protracted spawning period off northwest Puerto Rico from May to November. Females taken off Cape Hatteras, NC in June were found to have recently spawned (Rivas, 1975). Very few larvae have been collected in the western Atlantic, but some have been found off Georgia, in the Gulf of Mexico, off Cat Cay, Bahamas, and in the mid- north Atlantic (Nakamura, 1975; Ueyanagi *et al.*, 1970; W.J. Richards, pers. comm.). A few juveniles have been identified off Jamaica (Caldwell, 1962) and one from the Gulf of Mexico (W.J. Richards, pers. comm.).

Blue marlin are sexually mature by 2 to 4 years of age (SCRS, 1997). Female blue marlin begin to mature at approximately 104 to 134 lbs, while males mature at smaller weights, generally from 77 to 97 lbs. Analysis of egg (ova) diameter frequency suggests that blue marlin, white marlin, and sailfish spawn more than once, and possibly up to four times a year (de Sylva and Breder, 1997). During the spawning season blue marlin release from one million to ten million small (1 to 2 mm), transparent pelagic planktonic eggs (Yeo, 1978). The number of eggs has been correlated to interspecific sizes among billfish and size of individuals within the same species. Ovaries from a 324 lb female blue marlin from the northwest Atlantic were estimated to contain 10.9 million eggs, while ovaries of a 275 lb female were estimated to contain approximately 7 million eggs.

Fisheries: Blue marlin are targeted as a recreational fishery in the United States and Caribbean, and are also caught as bycatch of tropical tuna longline fisheries which use shallow gear deployment. They are also caught by offshore longline fisheries which target swordfish, especially in the western Atlantic, as well as by directed artisanal fisheries in the Caribbean. **U.S. Fishery Status:** Overfished. The effect of reduced stock size on habitat use, migrations or distribution is unknown but should be investigated in future research.

Growth and mortality: Blue marlin are believed to be one of the fastest growing of all teleosts in the early stages of development, and weigh between 30 and 45 kg by age 1 (SCRS, 1997). Based on analyses of daily otolith ring counts, they reach 24 cm LJFL (lower jaw fork length) in about 40 days, and about 190 cm LJFL in 500 days, with a maximum growth rate of approximately 1.66 cm/day occurring at 39 cm LJFL (Prince *et al.*, 1991). Fish larger than 190 cm LJFL tend to add weight more than length, making the application of traditional growth curve models, in which length or weight are predicted as a function of age, difficult for fish in these larger size categories. Females grow faster and reach much larger maximum sizes than males. Examination of sagitta (otolith) weight, body weight, and length/age characteristics indicate that sex-related size differences are related to differential growth between the sexes and not to differential mortality (Wilson *et al.*, 1991). Sexually dimorphic growth variation (weight only) in blue marlin appears to begin at 140 cm LJFL (Prince *et al.*, 1991). Somatic growth of male blue marlin slows significantly at about 220 lbs, while females continue substantial growth throughout their lifetime (Wilson *et al.*, 1991). Male blue marlin usually do not exceed 350 lbs, while females can exceed 1,200 lbs.

Blue marlin are estimated to reach ages of at least 20 to 30 years, based on analysis of dorsal spines (Hill *et al.*, 1990). Although this spine ageing technique has not been validated, longevity estimates are supported by tagging data. The maximum time at liberty recorded of a tagged individual was 4,024 days (about 11 years) for a blue marlin that was estimated to weigh 65 pounds at the time of release (SCRS, 1996b). Sagitta otolith weight is suggested to be proportional to age, indicating that both sexes are equally long-lived, based on the maximum otolith weight observed for each sex (Wilson *et al.*, 1991). Additionally, predicting age from length or weight is imprecise due to many age classes in the fishery (SCRS, 1996b). Estimates of natural mortality rates for billfish would be expected to be relatively low, generally in the range of 0.15 to 0.30, based on body size, behavior and physiology (SCRS, 1996b).

Habitat associations: Adults are found primarily in the tropics within the 24°C isotherm, and make seasonal movements related to changes in sea surface temperatures. In the northern Gulf of Mexico they are associated with the Loop Current, and are found in blue waters of low productivity rather than in more productive green waters. Off Puerto Rico the largest numbers of blue marlin are caught during August, September and October. Equal numbers of both sexes occur off northwest Puerto Rico in July and August, with larger males found there in May and smaller males in September (Rivas, 1975). Very large individuals, probably females, are found off the southern coast of Jamaica in the summer and off the northern coast in winter, where males are caught in December and January. Habitat information is summarized in Table 4.3.1.

<u>Essential Fish Habitat (EFH) for Blue Marlin (Figure 4.3.2a-d):</u>

- **Spawning, eggs and larvae:** Offshore Florida, identical to adult EFH in that area: from offshore Ponce de Leon Inlet (29.5 N) south to offshore Melbourne, FL from the 100 m isobath to 50 mi seaward (79.25 W); from offshore Melbourne, FL south to Key West from the100 m isobath to the EEZ boundary; also, off the northwest coast of Puerto Rico (from Arecibo to Mayaguez), bounded by the 2000 m isobath to the north and 18 N to the south.

- **Juveniles/Subadults (20-189 cm LJFL):** Pelagic surface waters not less than 24 C, offshore Delaware Bay to Cape Lookout, NC from the 100 to the 2000 m isobath, and grading further offshore to 73.25 W at 35 N; continuing south from offshore Cape Lookout to Cumberland Island, GA (30.75 N), from the 200 to 2000 m isobath; offshore St. Augustine, FL (30 N) south to 26 N, (Ft Lauderdale, FL) from the 100 m isobath offshore an additional 30 miles to 29 N , then south of 29 N, seaward from the 100 m isobath to the EEZ boundary; off southwest Florida from 24.5 N between the 200 m isobath and the EEZ boundary, north to 28 N, west to 86.25 W, and south to the EEZ boundary; offshore

Choctawhatchee Bay to Terrebonne Parish, LA, from the 100 to the 2000 m isobath, continuing west along the 200 m isobath to the Texas/Mexico border out to 2000 meters.

• **Adults (190 cm LJFL):** Pelagic surface waters not less than 24 C, from offshore Delaware Bay (38.5 N) south to offshore Wilmington, NC (33.5 N) between the100 and 2000 m isobaths; offshore Charleston, SC (32 N) from 100 m to 78 W to offshore the Georgia/Florida border (30.75 N); from offshore Ponce de Leon Inlet (29.5 N) south to offshore Melbourne, FL from the 100 m isobath to 50 mi seaward (79.25 W); from offshore Melbourne, FL south to Key West from the100 m isobath to the EEZ boundary; from offshore Choctawhatchee Bay (86 W) to offshore Terrebonne Parish, LA (90 W) between the100 and 2000 m isobaths; from Terrebonne Parish, LA south to offshore Galveston, TX (95 W) between the 200 and 2000 m isobaths; Puerto Rico and the U.S. Virgin Islands: from 65.25 W east and south to the EEZ northern boundary along the 100 m isobath. Also, off the northern shore of Puerto Rico out to the 2000 m isobath from 65.5 W west to the EEZ boundary, and along the southern coast of Puerto Rico out to the 2000 m isobath, east to 66.5 W.

White Marlin *(Tetrapturus albidus)*

Distribution: White marlin is an oceanic, epipelagic species that occurs only in the Atlantic Ocean. It inhabits almost the entire Atlantic from 45°N to 45°S in the western Atlantic and 45°N to 35°S in the eastern Atlantic. In the tropics white marlin usually occur above the thermocline in deep (depths greater than 100 m), blue waters with surface temperatures above 22°C and salinities of 35 to 37 ppt. They are usually in the upper 20 to 30 m of the water column but may go to depths of 200 to 250 m where the thermocline is deep. In higher latitudes, such as between New Jersey and Virginia, they are found commonly in shallow coastal waters (de Sylva and Davis, 1963). White marlin are found at the higher latitudes of their range only in the warmer months. Although they are generally solitary, they sometimes are found in small, usually same-age groups. White marlin spawn in tropical and sub-tropical waters and move to higher latitudes during the summer (Nakamura, 1985; Mather *et al.*, 1975). Catches in some areas may include a rare species, *Tetrapturus georgei*, which is superficially similar to white marlin (W.J. Richards, pers. comm.). The so-called "hatchet marlin" (Pristas, 1980) may also represent *T. georgei*, and has been caught occasionally in the Gulf of Mexico (D. de Sylva, pers. comm.). The similarity between species indicates some reported catches have the potential for error.

This species undergoes extensive movements, although not as extreme as those of the bluefin tuna and albacore. The longest distance traveled by a tagged and recaptured specimen, which had been at-large for 1.4 years, was 3,509 km. The longest time at-large recorded for a white marlin is 11.8 years. Transequatorial movements have not been documented for the species (Bayley and Prince, 1993). There have been 29,751 white marlin tagged and released by the CTC program, with 540 reported recaptures (1.8 percent of all releases). The majority of releases took place in the months of July through September, in the western Atlantic off the east coast of the United States. Releases of tagged white marlin also occurred off Venezuela, in the Gulf of Mexico, and in the central west Atlantic. As noted for blue marlin, the majority of recoveries occurred in the same general area as the original capture. The mean straight line distance of recaptured white marlin is 455 nm. A substantial number of individuals moved between the mid-Atlantic coast of the United States and the northeast coast of South America. Overall, 1.1 percent of documented white marlin recaptures have made trans-Atlantic movements. The longest movement was for a white marlin tagged during July, 1995 off the east coast near Cape May, NJ and recaptured off Sierra Leone, West Africa, in November, 1996. The fish traveled a distance of at least 3,519 nm over 476 days (1.3 years; Jones et. al., 1997).

Predator–prey relationships: The most important prey items of adult white marlin, at least in the Gulf of Mexico, are squid, dolphinfishes (*Coryphaena*) and hardtail jack (*Caranx crysos*), followed by mackerels, flyingfishes, and bonitos. Other food items found inconsistently and to a lesser degree include cutlassfishes, puffers, herrings, barracudas, moonfishes, triggerfishes, remoras, hammerhead sharks, and crabs. Along the central Atlantic coast food items include round herring (*Etrumerus teres*) and squid *(Loligo pealei*). Carangids and other fishes are consumed as well (Nakamura, 1985). Davies and Bortone (1976) found the most frequent stomach contents in 53 specimens from the northeastern Gulf of Mexico, off Florida and off Mississippi to include little tunny (*Euthynnus* sp.), bullet tuna (*Auxis* sp.), squid and moonfish

(*Vomer setapinnis*). They also found white marlin to feed on barracuda and puffer fish. The only predators of adult white marlin may be sharks and possibly killer whales (Mather *et al.*, 1975).

Reproduction and Early Life History: Sexual maturity of female white marlin is reached at about 61 inches LJFL (44 lbs). Mature females probably spawn more than once a year and possibly up to four times during the spawning season. The spawning season probably occurs only once a year, from March to June (de Sylva and Breder, 1997). It is believed there are at least three spawning areas in the western north Atlantic: northeast of Little Bahama Bank off the Abaco Islands, northwest of Grand Bahama Island, and southwest of Bermuda. Larvae have also been collected from November to April (Nakamura, 1985; Mather *et al.*, 1975), but these may have been sailfish larvae (*Istiophorus platypterus*), as the two can not readily be distinguished (W.J. Richards, pers. comm.)

Fisheries: White marlin are targeted as a recreational fishery in the United States and Caribbean, and are also caught as bycatch of tropical tuna longline fisheries which use shallow gear deployment. They are also caught by offshore longline fisheries which target swordfish, especially in the western Atlantic, as well as by directed artisanal fisheries in the Caribbean. **U.S. Fishery Status:** Overfished. The effect of reduced stock size on habitat use, migrations or distribution is unknown but should be investigated in future research.

Growth and mortality: Adult white marlin grow to over 280 cm TL (total length) and 82 kg. White marlin exhibit sexually dimorphic growth patterns; females grow larger than males (Nakamura, 1985; Mather *et al.*, 1975), but the dimorphic growth differences are not as extreme as noted for blue marlin (SCRS, 1997). A minimum estimate of longevity can be calculated from the longest time at liberty for a tagged white marlin, 4,305 days (11.8 years). The individual was estimated to weigh 50 lbs at the time of first capture, resulting in a minimum age estimate of 14 to15 years (SCRS, 1996b).

Habitat associations: The world’s largest sport fishery for the species occurs in the summer from Cape Hatteras, NC to Cape Cod, MA especially between Oregon Inlet, NC and Atlantic City, NJ. Successful fishing occurs up to 80 miles offshore at submarine canyons, extending from Norfolk Canyon in the mid-Atlantic to Block Canyon off eastern Long Island (Mather, *et al.*, 1975). Concentrations are associated with rip currents and weed lines (fronts), and with bottom features such as steep dropoffs, submarine canyons and shoals (Nakamura, 1985). The spring peak season for white marlin sport fishing occurs in the Straits of Florida, southeast Florida, the Bahamas, and off the north coasts of Puerto Rico and the Virgin Islands. In the Gulf of Mexico summer concentrations are found off the Mississippi River Delta, at De Soto Canyon and at the edge of the continental shelf off Port Aransas, TX, with a peak off the Delta in July, and in the vicinity of De Soto Canyon in August. In the Gulf of Mexico adults appear to be associated with blue waters of low productivity, being found with less frequency in more productive green waters. While this is also true of the blue marlin, there appears to be a contrast in the factors controlling blue and white marlin abundances, as higher numbers of blue marlin are caught when catches of white marlin are low and vice versa (Nakamura, 1985; Rivas, 1975). It is believed that white marlin prefer slightly cooler temperatures than blue marlin (D. de Sylva, pers.

comm.). Spawning occurs in early summer, in subtropical, deep oceanic waters with high surface temperatures and salinities (20 to 29°C and over 35 ppt). Spawning concentrations occur off the Bahamas, Cuba, and the Greater Antilles, probably beyond the U.S. EEZ, although the locations are unconfirmed. Concentrations of white marlin in the northern Gulf of Mexico and from Cape Hatteras to Cape Cod are probably related to feeding rather than spawning (Mather *et al.*, 1975). Habitat information is summarized in Table 4.3.2.

Essential Fish Habitat (EFH) for White Marlin (Figure 4.3.3a-c):

• **Spawning, eggs and larvae:** At this time the available information is insufficient to identify EFH for this life stage.

• **Juvenile/Subadult (20-158 cm LJFL):** Pelagic waters warmer than 22 C, from offshore the U.S. east coast from the 50 to the 2000 m isobath from the EEZ at Georges Bank at 41 N, south to offshore Miami, FL at 25.25 N; off the west coast of Florida, between the 200 and 2000 m isobath from 24.75 N to 27.75 N; then continuing between the 200 and 2000 m isobath west from 86 W to 93.5 W, then off the coast of Texas from west of 95.5 W to the 50 m isobath and south to the EEZ boundary.

• **Adults (159 cm LJFL):** Pelagic waters warmer than 22 C, from offshore the northeast U.S. coast from the 50 to the 2000 m isobath from 33.75 N to 39.25 N, then extending along 39.25 N out to the EEZ boundary; off the coast of South Carolina in the Charleston Bump area, in the region starting from the 200 m isobath at 32.25 N, east to 78.25 W, south to 31 N, west to 79.5 W and north to the 200 m isobath; offshore Cape Canaveral, FL from the 200 m isobath, east at 29 N to the EEZ boundary, south along the 200 m isobath and out to the EEZ boundary to 82 W, in the vicinity of Key West, FL; in the Gulf of Mexico, from 86.5 W to the EEZ boundary, along the 50 m isobath near De Soto canyon, then along the 100 m isobath west to the EEZ boundary offshore the United States/Mexico border.

Sailfish (*Istiophorus platypterus*)

Distribution: Sailfish have a circumtropical distribution (Post, 1998). They range from 40°N to 40°S in the western Atlantic and 50°N to 32°S in the eastern Atlantic. Sailfish are epipelagic and coastal to oceanic, and are usually found above the thermocline at a temperature range of 21 to 28°C, but may dive into deeper, colder water. These are the least oceanic of the Atlantic billfish, often moving to inshore waters. They are found over the shelf edge, and are associated with land masses (E. Houde, pers. comm.). However, they have been found to travel farther offshore than was previously thought.

A total of 62,740 sailfish have been tagged and released through the efforts of the CTC program, with reported recapture of 1,090 sailfish (1.7 percent of all releases). Most releases occurred off southeast Florida, from north Florida to the Carolinas, the Gulf of Mexico, Venezuela, Mexico, the northern Bahamas and the U.S. Virgin Islands. One tagged and recaptured specimen traveled from Juno, FL to the mid-Atlantic, a distance of 2,972 km (Bayley and Prince, 1993). The longest movement tracked by tagging was 3,509 km, with this specimen at-large for 1.4 yrs. The longest period a recaptured tagged animal was found to be at-large was 10.9 years (Bayley and Prince, 1993). During the winter sailfish are restricted to the warmer parts of their range and move farther from the tropics during the summer (Nakamura, 1985; Beardsley *et al.*, 1975). The summer distribution of sailfish does not extend as far north as for marlins. Tag-and-recapture efforts have recovered specimens only as far north as Cape Hatteras, NC. Few transatlantic or transequatorial movements have been documented using tag-recapture methods (Bayley and Prince, 1993).

Predator-prey relationships: Early larvae feed on copepods, but shift to eating fish when they reach 6.0 mm in size. The diet of adult sailfish caught around Florida consists mainly of pelagic fishes such as little thunny (*Euthynnus alletteratus*), halfbeaks (*Hemiramphus* spp.), cutlassfish (*Trichiurus lepturus*), rudderfish (*Strongylura notatus*), jacks (*Caranx ruber*), pinfish (*Lagodon rhomboides*), and squids, including *Argonauta argo* and *Ommastrephes bartrami* (Nakamura, 1985). Sailfish are opportunistic feeders and there is unexpected evidence that they may feed on demersal species such as sea robin (Triglidae), cephalopods and gastropods found in deep water. Sailfish in the western Gulf of Mexico have been found to contain a large proportion of shrimp in their stomachs (Nakamura, 1985; Beardsley *et al.*,1975). Davies and Bortone (1976) report that the stomach contents of 11 sailfish from the Gulf of Mexico most frequently contained little thunny, bullet tuna (*Auxis* sp.), squid and Atlantic moonfish (*Vomer setapinnis*). Adult sailfish are probably not preyed upon often, but predators include killer whales (*Orcinus orca*), bottlenose dolphin (*Tursiops turncatus*), and sharks (Beardsley et al., 1975).

Reproduction and Early Life History: Spawning has been reported to occur in shallow waters (30-40 ft) around Florida, from the Keys to the region off Palm Beach on the east coast. Spawning is also assumed, based on presence of larvae, offshore beyond the 100 m isobath from Cuba to the Carolinas, from April to September. However, the spawning has not been observed. Sexual maturity occurs in the third year, with females at a weight of 13 to18 kg and males at 10 kg (de Sylva and Breder, 1997). Sailfish are multiple spawners, with spawning activity moving northward in the western Atlantic as the summer progresses. Larvae are found in Gulf Stream waters in the western Atlantic, and in offshore waters throughout the Gulf of Mexico from March to October (de Sylva and Breder, 1997; Nakamura, 1985; Beardsley *et al.*,1975).

Fisheries: Sailfish are primarily caught in directed sportfisheries and as bycatch of the commercial longline fisheries for tunas and swordfish. Historically, nearly all sailfish from commercial catches have been reported as Atlantic sailfish; however, nearly all of these represent longbill spearfish (and perhaps other spearfish) and it is probable that very few sailfish are taken commercially in offshore waters of the Atlantic. Thus, it is impossible to determine historical trends in sailfish catches since at least two species have been combined. **U.S. Fishery Status:** Overfished.

Growth and mortality: Most sailfish examined that have been caught off Florida are under three years of age. Mortality is estimated to be high in this area, as most of the population consists of only two year classes (Beardsley *et al.*, 1975). Sailfish are probably the slowest growing of the Atlantic istiophorids. Sexual dimorphic growth is found in sailfish, but it is not as extreme as with blue marlin (SCRS, 1997). An individual sailfish that was recaptured after 5,862 days (16 years) at liberty can be used to estimate minimum age of longevity. Unfortunately, the size at release is not available for this fish (SCRS, 1996b). The maximum age can be 13 to15 or more years. Growth rate in older individuals is very slow - 0.59 kg/yr (Prince *et al.*, 1986).

Habitat associations: In the winter sailfish are found in schools around the Florida Keys and eastern Florida, in the Caribbean, and in offshore waters throughout the Gulf of Mexico. In the summer they appear to diffuse northward along the U.S. coast as far north as the coast of Maine, although there is a population off the east coast of Florida all year long. During the summer some of these fish move north along the inside edge of the Gulf Stream. After the arrival of northerlies in the winter they regroup off the east coast of Florida. Sailfish appear to spend most of their time above the thermocline, which occurs at depths of 10 to 20 m to 200 to 250 m, depending on location. The 28°C isotherm appears to be the optimal temperature for this species. Sailfish are mainly oceanic but migrate into shallow coastal waters. Larvae are associated with the warm waters of the Gulf Stream (Nakamura, 1985; Beardsley *et al.*, 1975; Post, 1998). Habitat information is summarized in Table 4.3 .3.

<u>Essential Fish Habitat (EFH) for Sailfish (Figure 4.3.4a-c):</u>

• **Spawning, eggs and larvae:** From 28.25 N south to Key West, FL, associated with waters of the Gulf Stream and Florida Straits from 5 mi offshore out to the EEZ boundary.

• **Juveniles/Subadults (20-142 cm LJFL):** In pelagic and coastal surface waters between 21 and 28 C, from 32 N south to Key West, FL in waters from 5 mi offshore to125 mi offshore, or the EEZ boundary, whichever is nearer to shore; west of Key West, FL, all waters of the Gulf of Mexico from the 200 to the 2000m isobath or the EEZ boundary, whichever is nearer to shore.

• **Adults (143 cm LJFL):** In pelagic and coastal surface waters between 21 and 28 C, offshore of the U.S. southeast coast from 5 mi off the coast to 2000 m, from 36 N to 34 N, then from 5 mi offshore to 125 mi offshore, or the EEZ boundary, whichever is nearer to shore, south to Key West, then from the 200 m isobath to the 2000 m isobath. Additional EFH is delineated in the Gulf of Mexico near De Soto Canyon up to the 50 m isobath, and areas 5 mi offshore southeast Texas, from Corpus Christy to the EEZ boundary, or the 2000 m isobath, whichever is closer.

Longbill Spearfish ***(Tetrapturus pfluegeri)***

Distribution: Only relatively recently (1963) has the longbill spearfish been reported as a new (distinct) species. It is known, but rare, from off the east coast of Florida, the Bahamas and the Gulf of Mexico, and from Georges Bank to Puerto Rico. More recently it has been observed to be more widely distributed, mostly in the western Atlantic. The range for this species is from 40°N to 35°S. It is an epipelagic, oceanic species, usually inhabiting waters above the thermocline (Nakamura, 1985; Robins, 1975). The species is generally found in offshore waters.

Predator-prey relationships: The diet of the longbill spearfish consists of pelagic fishes and squids. However, little data for diet specific to fish in the north Atlantic is available.

Life history: Spawning is thought to occur in widespread areas in the tropical and subtropical Atlantic (Nakamura, 1985) in the winter from November to May (de Sylva and Breder, 1997). There are a few records of larvae caught near the Mid-Atlantic Ridge from December to February, and in the Caribbean (de Sylva and Breder, 1997; Ueyanagi *et al.* , 1970; W.J. Richards, pers. comm.).

Fisheries: Longbill spearfish is not a target species, but is taken in the recreational fishery; the sportfishery catches only about 100 individuals per year. It is, however, taken as bycatch of the tuna longline fishery. **U.S. Fishery Status:** Unknown.

Growth and mortality: The maximum weight of females at first maturity is approximately 45 kg (de Sylva and Breder, 1997).

Habitat associations: The species ranges farther offshore than sailfish. Nothing is known about its habitat associations. Habitat information is summarized in Table 4.3.4.

Essential Fish Habitat (EFH) for Longbill Spearfish (Figure 4.3.5a-c):

- **Spawning, eggs and larvae:** At this time available information is insufficient to describe and identify EFH for this life stage.

- **Juvenile/Subadult (~20-182 cm LJFL):** Offshore North Carolina, from 36.5 N to 35 N, from the 200 m isobath to the EEZ boundary.

- **Adults (183 cm LJFL):** The Charleston Bump area of the South Atlantic Bight from 78 W to 79 W, and from 37 N to 31 N; and southwest of the U.S. Virgin Islands from 65 W east to the EEZ boundary or the 2000 m isobath, whichever is nearer to shore.

4.4 Threats to Essential Fish Habitat

This section identifies the principal fishing and non-fishing related threats to billfish EFH, as identified and described in Section 4.3 of this amendment. It also provides examples and information concerning the relationship between those threats and EFH, and describes conservation and enhancement measures that can lessen the adverse impact on EFH. Other information sources and examples likely exist, and many new studies are underway or in various stages of completion or publication. Accordingly, the following discussion is presented as a starting point in the identification of threats to billfish EFH and is intended to satisfy requirements of the Magnuson-Stevens Act. The habitat provisions of this amendment represent an initial step in identifying EFH and the threats to EFH, and provides a framework for continuing to focus attention on this critical area of fishery management. It is intended to stimulate further discussion, research and analyses that can be used to update and improve future versions of this document.

From the broadest perspective, fish habitat is the geographic area where the species occurs at any time during its life. Habitat area can be described in terms of location; physical, chemical and biological characteristics, and time. Ecologically, habitat includes structure or substrate that focuses distribution (e.g., coral reefs, topographic highs, areas of upwelling, frontal boundaries, particular sediment types, or submerged aquatic vegetation) and other characteristics that are less distinct but are still crucial to the species' continued use of the habitat (e.g., turbidity zones, salinity, temperature or oxygen gradients).

Species use habitat for spawning, breeding, migration, feeding and growth, and for shelter from predation to increase survival. Spatially, habitat use may shift over time due to changes in life history stage, abundance of the species, competition from other species, and environmental variability in time and space. Species distributions and habitat use can be altered by habitat change and degradation resulting from human activities and impacts, or other factors. The type of habitat available, its attributes, and its functions are important to species productivity, diversity and survival.

The role of habitat in supporting the productivity of organisms has been well documented in the ecological literature and the linkage between habitat availability and fishery productivity has been examined for several fishery species. Because habitat is an essential element for sustaining the production of a species and, therefore the fisheries based on those species, the goals of FMPs cannot be achieved if the managed species do not have sufficient quantities of suitable habitat available for each life stage.

The quantitative relationships between fishery production and habitat are very complex and no reliable models currently exist. Accordingly, the degree to which habitat alterations have affected fishery production to date is unknown. In one of the few studies that has been able to investigate habitat-fishery productivity dynamics, Turner and Boesch (1987) examined the relationship between the extent of wetland habitats in the Gulf of Mexico and the yield of fishery species dependent on coastal bays and estuaries. They found correlations between reduced fishery stock production following wetland losses, and stock gains following increases in the areal extent of wetlands. While most of these types of studies examined shrimp or menhaden productivity, other fisheries show varying degrees of dependence on particular habitats and likely follow similar trends. Accordingly, a significant threat facing fishery production is the loss of habitat due to natural and/or anthropogenic causes.

Species of the Atlantic billfish fishery utilize diverse habitats that have been identified as essential to various life stages. Pelagic species (or life stages), such as the blue marlin and white marlin, are most often associated with areas of convergence or oceanographic fronts such as those found over submarine canyons, the edge of the continental shelf or the boundary currents (edge) of the Gulf Stream. Although there is no substrate or hard structure in the traditional sense, these water column habitats can be characterized by their physical, chemical, and biological characteristics.

4.4.1 Fishing Activities That May Adversely Affect EFH

The Magnuson-Stevens Act requires that the fishery management councils (Councils) identify adverse effects on EFH caused by fishing activities, and further requires that Councils manage the fisheries under their jurisdictions so as to minimize such impacts, to the extent practicable. The EFH regulations explain that “adverse effects from fishing may include physical, chemical, or biological alterations of the substrate, and loss of, or injury to, benthic organisms, prey species and their habitat, and other components of the ecosystem.” Further, the regulations require that FMPs contain an assessment of the potential adverse effects of all fishing gear and practices used in waters described as EFH. The assessment should consider the relative impacts of gears on all different types of EFH identified. Special consideration is to be given to the analysis of impacts from gears that will affect Habitat Areas of Particular Concern (HAPC).

The EFH regulations also require that FMPs include management measures that minimize adverse effects on EFH from fishing, to the extent practicable. To decide if minimization of an adverse effect from fishing is practicable, the Council (NMFS) must consider: 1) whether, and to what extent, the fishing activity is adversely impacting EFH, including the fishery; 2) the nature and extent of the adverse effect on EFH; and 3) whether the management measures are practicable, taking into consideration the long and short-term costs as well as the benefits to the fishery and its EFH, along with other appropriate factors consistent with National Standard 7. Councils are advised to use the best scientific information available, as well as other appropriate information sources, as available. Where information gaps are identified through the assessment process, Councils should consider the establishment of research closure areas and other measures to evaluate the impact of any fishing activity that physically alters EFH.

This section includes an assessment of fishing gears and practices that are used in the billfish fishery, accompanied by conservation recommendations to minimize the potential impacts. Also included is a brief discussion of the scientific review of information relating to fishing impacts on habitat. In recent reviews of fishing impacts on habitat, Jennings and Kaiser (1998) and Auster and Langton (1998) characterize fishing impacts hierarchically; impacts to structural components of habitat, effects on community structure, and effects on ecosystem processes. In this section the impacts of the billfish fishing activities will be addressed in the same format, followed by comments on non-HMS fishing impacts on billfish EFH, and also the identification of research priorities to provide additional information that can be used to improve future amendments to the EFH provisions.

Physical Impacts of Billfish and HMS Fishing Gears on EFH

The following gears have been identified for the HMS Billfish fishery:

Atlantic Billfish

Fishery (Recreational only)	**Approved Gear Type**
A. Hook and line fishery	A. Rod and reel, handline.

Billfish, the target species from this HMS fishery management unit, are associated with hydrographic structures in the water column, e.g., convergence zones or boundary areas between different currents. Because of the magnitude of these water column structures and the processes that cause them, there is little effect that can be detected from the fishing activities undertaken to pursue these animals. None of the gears specified for the billfish fishery contact the substrate underlying the waters in which these species are targeted. Fishery scientists have recently begun to express concern over the use of lead weights in inshore and inland fisheries. In lakes or streams the concentration of elemental lead has increased to a level that causes concern over its continued use as fishing tackle. Considering the expanse over which billfishing occurs, this is probably not a threat to the continued health of billfish EFH, but it should be kept in mind for future consideration of research topics. Based on the available information, the impacts from billfish fishing gears can be assumed to be negligible on billfish EFH.

Since there is considerable overlap in areas fished for billfish and other HMS, the gears that are used in other HMS fisheries have the potential to adversely impact billfish EFH. Of the approved gears in those fisheries, bottom longlines, principally set for sharks, can contact the bottom substrate. Gear could become hung or entangled on various elements of the substrate including rocks, boulders, hard- or live-bottoms, hard or soft corals. In instances where billfish are attracted to the habitat due to hydrographic characteristics, i.e., up-welling, convergences, etc., the scale of impact is probably not of sufficient magnitude to affect the characteristics of the habitat. If, however, the fish are attracted because of prey resources, the prey may be dependent on habitat characteristics that could be altered at these scales. NMFS recommends that fishermen take appropriate measures to identify bottom obstructions and avoid setting gear in areas where it may become entangled and potentially disrupt benthic habitats. If gear is lost, diligent efforts should be made to recover the lost gear to avoid further fouling (disturbance) of the underwater habitat through "ghost fishing."

Population and Ecosystem Impacts of Removing Target Species

There is currently a great deal of interest in the ecosystem level effects of removing apex predators from aquatic systems. Although there has not been extensive research in this field, there are a few examples where population or ecosystem effects have been inferred from fishing activities. Branstetter (1997) suggests that increased survival of young tiger, dusky and sandbar sharks may be due to the removal of large sharks that ordinarily prey upon these juveniles. There is some evidence that removal of large sharks in coastal waters of South Africa has resulted in a proliferation of small shark species (Buxton, pers. comm.). Overfishing of cod in the northwest Atlantic has led to apparent "species replacement" where dogfish (sharks) have proliferated and assumed the ecological role previously held by cod. At the present time it is believed that it may be difficult if not impossible to reverse the trend and re-establish cod populations.

Natural ecosystems maintain a dynamic equilibrium that will ensure stability, within natural variation, as long as ecological disturbance is neither too intense nor too frequent. Removal of one trophic level (e.g., apex predators) would be considered a disturbance to the system. At moderate levels of disturbance, populations and ecosystems are likely able to compensate and maintain their biological integrity. Continued high rates of removal of billfish adults and late juveniles (top predators) might constitute a frequent and intense disturbance with the capacity to induce changes in the biological characteristics of the habitat. Continued disturbance could result in unforeseen ecological changes, detrimental to the long-term productivity of the billfish species resulting from changes in the biological characteristics of EFH. Time/area closures, reducing the bycatch or capture of juvenile billfish, should be considered in the future as a risk-averse method to avoid changes to the biological characteristics of billfish EFH and to help ensure the biological integrity of the habitats. Research into cascading ecological effects from apex predator removal should be encouraged.

Impacts on HMS EFH from non-HMS Fishing Gears and Practices

Because some billfish use both offshore and inshore habitats (e.g., sailfish spawning in coastal habitats off southeastern Florida), billfish EFH may be negatively impacted by fisheries that target species other than billfish. These fisheries may be either state or federally managed. Trawl fisheries that scrape the substrate, disturb boulders and their associated epiphytes or epifauna, re-suspend sediments, flatten burrows and disrupt seagrass beds have the potential to alter the habitat characteristics that are important for the survival of early live stages of many of the targeted and non-targeted species.

The degree of impact and long term habitat modification depends on the severity and frequency of the impacts as well as the amount of recovery time between impacts (Auster and Langton, 1998). The extent to which particular parameters are altered by trawl gear is somewhat dependent on the configuration of the gear and the manner in which the gear is fished.

Additional efforts are required to study the EFH areas that are fished for non-HMS species and identify fishing gears that impact habitat. In this regard, coordination efforts should be undertaken with the respective Councils to identify potential common areas. Research into the frequency of disturbance and the changes induced in the habitat are of primary importance. A better understanding of the habitat characteristics that influence the abundance of managed species within those habitats is needed in order to understand the effects of fishing activities on habitat suitability for HMS.

Besides altering the physical characteristics of EFH, other fisheries may remove prey species that make up the necessary biological components of billfish EFH. As an example, development or expansion of a squid fishery off the Atlantic coast has the potential to degrade the quality of EFH for billfish and other HMS since many of these species utilize a high percentage of squid in their diets. Research into the dynamics of these interactions between fisheries should be investigated for future consideration. If there is evidence that another fishery is depleting the resources associated with the EFH of billfish, the issue of resource allocation will need to be addressed with the appropriate Council(s).

Additionally, other fisheries may remove habitat components that are important to the integrity of billfish EFH. Many of these impacts have been addressed in other fishery management plans (e.g., SAFMC; GMFMC) that focus on restricting the removal of attached species such as corals or kelp that provide essential structure to their respective habitats; however, for pelagic species other biological components must be considered. Some billfish life stages have been found to be associated, or to co-occur, with floating mats of the brown algae, *Sargassum* sp. The mats are pelagic and are moved extensively by winds and currents. They are frequently found in convergence zones, windrows, or at current boundaries - areas that are EFH for some of the billfish life stages. Whether the floating mats serve as shelter, act as a source of prey (because of the abundance of prey species associated with the mats), serve as a means of camouflage, or serve some other biological function is not entirely clear. It is a biological component that may focus, particularly on the small scale, the distribution of certain life stages of the billfish, and it should be maintained in its habitat. Under the Magnuson-Stevens Act definitions, harvesting of *Sargassum* would qualify as a "fishing activity." As such, NMFS has been urged by the Billfish Advisory Panel to make strong recommendations against the harvest, possession, or landing of *Sargassum* within the U.S. EEZ. In order for this recommendation to be enforceable, it must also include recommendations that no *Sargassum* can be possessed or landed within the United States since it would be impossible to verify if this *Sargassum* was harvested outside the EEZ and simply transported back into U.S. waters for landing. Harvest of *Sargassum* is under the jurisdiction of the South Atlantic Fishery Management Council and will be phased out under the Council's new FMP.

EFH Conservation Recommendations

The EFH regulations require that Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing practice is having an identifiable adverse effect on EFH, based on the assessment of fishing gears on EFH.

At this time, there is no evidence that physical effects caused by fishing under this amendment are adversely affecting billfish EFH to the extent that detrimental effects can be identified on the habitat or the fisheries. Conservation recommendations discussed above as NMFS' suggestions should help to mitigate any impacts that are currently occurring but unverified. Additional study will be recommended to more adequately identify unrealized adverse impacts and to quantify impacts currently happening.

Time/area closures could also be considered as a conservation measure that would help to maintain the biological integrity of billfish EFH and reduce the chance of altering the biological characteristics of the EFH. By preserving more of the age structure in the population and a diversity of trophic levels, the measure could lend added stability to the ecosystem upon which the billfish fishery depends. From an EFH perspective time/area closures would be seen as a desirable step toward conserving and enhancing billfish EFH.

Any inshore areas that are identified as billfish EFH could be considered for restriction of HMS or non-HMS fishing in order to study the effects of gear impacts on billfish EFH. Research in these areas should be strongly advocated.

Further evaluations of fishing impacts on habitat will be undertaken as more research is conducted and information becomes available. Information will be reviewed annually to assess the state of knowledge in this field. Future revisions of the habitat (and EFH) provisions in this amendment will include any new information on the impacts of fishing activities on fish habitat, including EFH.

4.4.2 Non-fishing Threats to EFH

Section 600.815 (a)(5) of the EFH regulations requires that FMPs identify non-fishing related activities that may adversely affect EFH of managed species, either quantitatively or qualitatively, or both. In addition, Section 600.815 (a)(7) of the regulations requires that FMPs recommend conservation measures describing options to avoid, minimize, or compensate for the adverse effects identified. As the jurisdiction and the EFH of this FMP amendment overlaps with the EFH identified by the respective Councils of the eastern United States, the threats to EFH and conservation measures compiled for this document are a synthesis of those listed in the Councils' EFH amendments. The information in this section has been adapted, with permission, from EFH amendments prepared by the Mid-Atlantic (MAFMC, 1998), South Atlantic (SAFMC, 1998) and Gulf of Mexico (GMFMC, 1998) Councils. Original sources of information are cited in those documents.

Broad categories of activities that may adversely affect EFH include, but are not limited to: (1) actions that physically alter structural components or substrate, e.g., dredging, filling, excavations, water diversions, impoundments and other hydrologic modifications; (2) actions that result in changes in habitat quality, e.g., point source discharges, activities that contribute to non-point source pollution and increased sedimentation, introduction of potentially hazardous materials, or activities that diminish, or disrupt the functions of EFH. If these actions are persistent or intense enough, they can result in major changes in habitat quantity as well as quality, or can result in conversion of habitats, or complete abandonment of habitats by some species.

Estuaries and coastal and offshore waters are used by humans for a variety of purposes that often result in some degree of degradation of these and adjacent environments, posing threats, either directly or indirectly, to the associated biota. These effects, either alone or in combination with (cumulative) effects from other activities within the ecosystem, may contribute to the decline of some species or biological components of the habitat. In many cases such effects may be demonstrated, but often they are difficult to quantify.

Pollutants (e.g., heavy metals, oil and grease, excess nutrients, improperly treated human and animal wastes, pesticides, herbicides and other chemicals) can be introduced into the aquatic environment through a number of routes, including point sources, non-point sources, and atmospheric deposition. These types of contaminants have been demonstrated to affect finfish and crustacea by altering the growth, visual acuity, swimming speed, equilibrium, feeding rate, response time to stimuli, predation rate, spawning seasons, migration routes and resistance to disease and parasites finfish and crustacea finfish and crustacea. In addition to the introduction of contaminants that cause direct effects on animal physiology, point source discharges have also affected essential habitat characteristics such as water flow, temperature, pH, dissolved oxygen, salinity, and other parameters that affect habitat suitability for individuals, populations and communities. The synergistic effects of multiple discharge components such as heavy metals and various chemical compounds are not well understood but are increasingly of concern in research efforts. More subtle effects of contaminants, such as endocrine disruption in aquatic organisms and reduced ability to reproduce or compete for food, are also being identified and investigated.

Non-point source runoff may have a more significant impact on coastal water quality, particularly since tighter controls on point source discharges have been instituted. Activities that tend to increase the input of contaminants to aquatic environments through non-point sources include coastal development, urban runoff, inappropriate agriculture and silviculture practices, marinas and recreational boating, and hydromodification. Related activities, such as the use of septic systems and improper disposal or treatment of wastes, can contribute biological contaminants, as well. Many of these activities can result in large quantities of pesticides, nutrients, and pathogens in coastal waters. Excess nutrification is one of the greatest sources of coastal water contamination. Nutrient overenrichment can lead to noxious algal blooms, fish kills, and oxygen depletion (as hypoxic or anoxic events). Researchers have found reduced or stressed fisheries populations to be common in areas where hypoxia occurs.

As required under the EFH regulations, the following discussion identifies activities having the potential to adversely affect billfish EFH. In many cases these activities are regulated under various statutory authorities. As long as they are regulated within those guidelines, their potential to adversely affect EFH may be reduced, although not necessarily eliminated. Many of the standards that are used to regulate these activities are based on human health needs and do not consider long term impacts on fish or fish habitats. Additionally, if the activity fails to meet or is operated outside its permitted standards, it may adversely affect EFH. The EFH regulations require NMFS and the Councils to identify actions with the *potential* (emphasis added) to adversely affect EFH, including its biological, chemical and physical characteristics. The EFH regulations also recommend the examination of cumulative impacts on EFH, and it is possible that many permitted actions, operating within their regulatory bounds, may cause adverse impacts on EFH. The following sections list a broad range of activities to ensure that their potential to adversely affect billfish EFH has been identified.

The review of habitat use undertaken for this chapter identified both benthic and water column habitats in offshore and coastal areas as EFH, although in many cases the particular habitat characteristics that control species habitat use are not clearly identified. Many of these factors appear to be related to water quality (e.g., temperature, salinity, dissolved oxygen). Therefore, water quality degradation has been a primary focus in this section. When analyzing the impacts that water quality changes can have on billfish EFH, it is important to examine all habitats. EFH for billfish includes offshore areas, but even these distant habitats can be affected by actions that originate in coastal habitats (both terrestrial and aquatic) and adjacent estuaries. Some billfish aggregate over submarine canyons or along river plumes; these physiographic features can serve as conduits for currents moving from inshore out across the continental shelf and slope, carrying and redistributing contaminants from the nearshore realm to offshore habitats. Until the precise zones of influence from various river and coastal discharges can be delineated, a precautionary approach should be taken in order to protect the integrity of billfish EFH and the sustainability of the billfish fishery.

In addition to identifying activities with the potential to adversely affect EFH, the Magnuson-Stevens Act and the EFH regulations require the inclusion of measures to conserve and enhance EFH. Each activity discussed below is followed by conservation measures to avoid, minimize or mitigate adverse effects on EFH. These include examples of both general and specific conservation measures that might be appropriate for NMFS to include as part of its conservation recommendations to Federal and state agencies on activities similar to those discussed below. In some cases the measures are based on site-specific activities; in others they represent broad policy type guidelines. It should be understood that during EFH consultation, each project will be evaluated on its merits, and the threat to EFH and appropriate conservation measures will be assessed at that time. The Federal action agency with the statutory authority to regulate the proposed action weighs the recommendations of all commenters and decides on the appropriate action, modifications or mitigation before proceeding with a project. The conservation measures included in this amendment are meant to be examples of NMFS recommendations that might be made regarding particular projects. They are intended to assist Federal and state agencies and other entities during the planning process when minimization of adverse impacts on EFH can most effectively be incorporated into project designs and goals.

4.4.2.1 Marine Sand and Minerals Mining

Mining for sand (e.g., for beach nourishment projects), gravel, and shell stock in estuarine and coastal waters can result in water column effects by changing circulation patterns, increasing turbidity, and decreasing oxygen concentrations at deeply excavated sites where flushing is minimal. Ocean extraction of mineral nodules is a possibility for some non-renewable minerals now facing depletion on land. Such operations are proposed for the continental shelf and the deep ocean proper. Deep borrow pits created by mining may become seasonally or permanently anaerobic. Marine mining also elevates suspended materials at mining sites, creating turbidity plumes that may move several kilometers from these sites. Resuspension of sediments can affect water clarity over wide areas, and could also potentially affect pelagic eggs and larvae. In addition, resuspended sediments may contain contaminants such as heavy metals, pesticides, herbicides, and other toxins.

Conservation Measures:

- Sand mining and beach nourishment should not be allowed in or adjacent to billfish EFH during seasons when billfish are utilizing the area, particularly during spawning seasons.

- Gravel extraction operations should be managed to avoid or minimize impacts to the bathymetric structure in estuarine and nearshore areas.

- An integrated environmental assessment, management, and monitoring program should be a part of any gravel or sand extraction operation, and encouraged at federal and state levels.

- Planing and design of mining activities should avoid significant resource areas important as billfish EFH.

- Mitigation and restoration should be an integral part of the management of gravel and sand extraction policies.

4.4.2.2 Offshore Oil and Gas Operations

Offshore oil and gas operations (exploration, development, production, transportation and decommissioning) pose a considerable level of potential threat to marine ecosystems. Exploration and recovery operations may cause substantial localized bottom disturbance. However, more pertinent to billfish is the threat of contaminating operational wastes associated with offshore exploration and development, the major operational wastes being drilling muds and cuttings and formation waters. In addition, there are hydrocarbon products, well completion and work-over fluids, spill clean-up chemicals, deck drainage, sanitary and domestic wastes, ballast water, and the large volume of unrefined and refined products that must be moved within the offshore and coastal waters. Potential major contaminants used in oil and gas operations may be highly saline; have low pH; contain suspended solids, heavy metals, crude oil compounds, and organic acids; or may generate high biological and chemical oxygen demands. Also, accidental discharges of oil - crude, diesel and other hydrocarbon products - and chemicals can occur at any stage of exploration, development, or production, the great majority of these being associated with product transportation activities. Blowouts and associated oil spills can occur at any operational phase when improperly balanced well pressures result in sudden, uncontrolled releases of petroleum hydrocarbons. To remove fixed platforms explosives are frequently used. All of these activities result in harmful effects on marine water quality as well as the biota in the vicinity.

In the Gulf of Mexico Outer Continental Shelf (OCS) oil and gas operations are extending to deeper and deeper waters throughout which billfish are known to range. Locations such as the De Soto Canyon area in the northern Gulf and the Blake Plateau north of the Bahamas repeatedly appear in the analysis of billfish EFH as highly productive areas important to these species. Oil and gas production in these areas should be discouraged because of the potential impact to billfish EFH in these areas.

Considerable documentation exists that highlights the benefits of offshore production platforms as artificial reefs that attract numerous species of fishes, including highly migratory pelagic species. It is likely that the attraction of these species to the platforms increases the potential for exposure to contaminants they may release into the aquatic environment.

Conservation Measures:

- A plan should be in place to avoid the release of hydrocarbons, hydrocarbon-containing substances, drilling muds, or any other potentially toxic substance into the aquatic environment. Storage of these materials should be in enclosed tanks whenever feasible or, if not, in lined mud pits or other approved sites. Equipment should be maintained to prevent leakage. Catchment basins for collecting and storing surface runoff should be included in the project design.

- Exploration/production activities and facilities should be designed and maintained in a manner that will maintain natural water flow regimes, avoid blocking surface drainage, and avoid erosion in adjacent coastal areas.

- Activities should avoid wetlands. Drilling should be conducted from uplands, existing drill sites, canals, bayous or deep bay waters (greater than six feet), wherever possible, rather than dredging canals or constructing board roads. When wetland use is unavoidable, work in previously disturbed wetlands is preferable to work in high quality or undisturbed wetlands. If this is not possible, temporary roads (preferably board roads) to provide access are more desirable than dredging canals because roads generally impact less acreage and are easier to restore than canals. If the well is a producer, the drill pad should be reduced to the minimum size necessary to conduct production activities and the disturbed area should be restored to pre-project conditions.

- Upon completion or abandonment of wells in wetlands, all unnecessary equipment should be removed and the area restored to pre-project elevations. The well site, various pits, levees, roads and other work areas should be graded to pre-project marsh elevations and then restored with indigenous wetland vegetation. Abandoned canals frequently need plugging and capping with erosion-resistant material at their origin to minimize bank erosion and to prevent saltwater intrusion. In addition, abandoned canals will frequently need to be backfilled to maximize fish and wildlife production in the area and to restore natural sheet flows. Spoil banks containing uncontaminated materials should be backfilled into borrow areas or breached at regular intervals to re-establish hydrological connections.

- In open bays maximum use should be made of existing navigable waters already having sufficient width and depth for access to the drill sites.

- An oil spill response plan should be developed and coordinated with federal and state resource agencies.

- Activities on the OCS should be conducted so that petroleum-based substances such as drilling mud, oil residues, produced waters, or other toxic substances are not released into the water or onto the sea floor: drill cuttings should be shunted through a conduit and discharged near the sea floor, or transported ashore or to less sensitive, NMFS-approved offshore locations; drilling and production structures, including pipelines, generally should not be located within one mile of the base of a live reef.

- Prior to pipeline construction, less damaging, alternative modes of oil and gas transportation should be explored.

- State natural resource agencies should be involved in the preliminary pipeline planning process to prevent violations of water quality and habitat protection laws and to minimize impact of pipeline construction and operation on aquatic resources.

- Pipeline alignments should be located along routes that minimize damage to marine and estuarine habitat. Buried pipelines should be examined periodically for maintenance of adequate earthen cover.

- All vessels transporting fuels and other hazardous materials should be required to carry equipment to contain and retrieve the spill. Dispersants shall not be used to clean up fuels and hazardous materials unless approved by the EPA/Coast Guard and fishery agencies.

- NPDES permit conditions such as those relating to dissolved oxygen, temperature, impingement and entrainment, under the Clean Water Act should be monitored and strictly enforced in areas that could affect billfish EFH.

- NPDES permits should be reviewed every five years for all energy production facilities.

4.4.2.3 Coastal Development

Coastal development activities include urban, suburban, commercial and industrial construction, along with development of corresponding infrastructure. These activities may result in erosion and sedimentation, dredging and filling (see following subsection), point and non-point source discharges of nutrients, chemicals, and cooling water into estuarine, coastal and ocean waters. Industrial point source discharges can result in the contamination of water and degradation of water quality by introducing organics and heavy metals or altering other characteristics such as pH and dissolved oxygen. Improperly treated sewage treatment effluent has been shown to produce changes in water quality as a result of chlorination and increased contaminant loading, including solids, phosphorus, nitrogen and other organics, and human pathogens and parasites. Non-point source pollution - that which results from land runoff, atmospheric deposition, drainage, groundwater seepage, or hydrologic modification - results in the deposition of pathogens, nutrients, sediments, heavy metals, oxygen demanding substances, road salts, hydrocarbons and other toxics.

Coastal development can also lead to the destruction of coastal wetlands, resulting in the elimination of protective buffer zones that serve to filter sediments, nutrients, and contaminants - such as heavy metals and pesticides - that are transported to the coastal zone in ground and surface waters. In addition, hydrological modifications associated with coastal development alter freshwater inflow to coastal waters, resulting in changes in salinity, temperature, and nutrient regimes, and thereby contributing to further degradation of estuarine and nearshore marine habitats. The variety of pollutants and the severity of their effects from coastal development activities depend upon a number of factors, such as the nature of the construction, physical characteristics of the site involved, and proximity of the pollutant source to the coastline. However, all of these factors ultimately can serve to degrade estuarine and coastal water quality to some degree in terms of dissolved oxygen levels, salinity concentrations, and contaminants.

Conservation Measures:

- Adverse impacts resulting from construction should be avoided whenever practicable alternatives are identified. For those impacts that cannot be avoided, minimization through implementation of Best Management Practices (BMPs) should be employed. For those impacts that can neither be avoided nor minimized, compensation through replacement of equivalent functions and values should be required.

- Coastal development traditionally has involved dredging and filling of shallows and wetlands, hardening of shorelines, clearing of riparian vegetation, and other activities that adversely affect the habitats of living marine resources. Mitigative measures should be required for all development activities with the potential to degrade billfish EFH, whether conducted within the EFH or in areas that influence billfish EFH.

- Destruction of wetlands and shallow coastal water habitats should not be permitted in areas adjacent to billfish EFH. Mitigation or compensation measures should be employed where destruction is unavoidable. Project proponents should demonstrate that project implementation will not negatively affect billfish, their habitat, or their food sources.

- Flood control projects in waterways draining into EFH should be designed to include mitigation measures and constructed using BMPs. For example, stream relocation and channelization should be avoided whenever practicable. However, should no practicable alternatives exist, relocated channels should be of comparable length and sinuosity as the natural channels they replace to maintain the quality of water entering receiving waters (i.e., billfish EFH).

- Watershed protection/site development should be encouraged. Comprehensive planning for development on a watershed scale (and for small-scale site development as well) should be undertaken, including planning and designing to protect sensitive ecological areas, minimizing land disturbances and retaining natural drainage and vegetation whenever possible. To be truly effective, watershed planning efforts should include existing facilities even though they are not subject to EFH consultation.

- Pollution prevention activities, including techniques and activities to prevent non-point source pollutants from entering surface waters, should be implemented. Primary emphasis should be placed on public education to promote methods for proper disposal and/or recycling of hazardous chemicals, management practices for lawns and gardens, onsite disposal systems (OSDSs), and commercial enterprises such as service stations and parking lots.

- Construction erosion/sediment control measures should be used to reduce erosion and transport of sediment from construction sites to surface waters. A sediment and erosion control plan should be developed and approved prior to land disturbance.

- Runoff from new development should be managed so as to meet two conditions: (1) the average annual total suspended solids loadings after construction is completed are no greater than pre-development loadings; and (2) to the extent practicable, post-development peak runoff rate and average volume are maintained at levels that are similar to pre-development levels.

- Construction site chemical control measures should address the transport of toxic chemicals to surface water by limiting the application, generation, and migration of chemical contaminants (i.e., petrochemicals, pesticides) and providing proper storage and disposal.

- New OSDSs should be built to reduce nutrient/pathogen loadings to surface waters. OSDSs should be designed, installed and operated properly and to be situated away from open waterbodies and sensitive resources such as wetlands, and floodplains. Protective separation between the OSDS and the groundwater table should be established. The OSDS unit should be designed to reduce nitrogen loadings in areas where surface waters may be adversely affected. Operating OSDSs should prevent surface water discharges and reduce pollutant loadings to ground water. Inspection at regular intervals and repair or replacement of faulty systems should occur.

- Roads, highways, bridges and airports should be situated away from areas that are sensitive ecosystems and susceptible to erosion and sediment loss. The siting of such structures should not adversely impact water quality, should minimize land disturbances, and should retain natural vegetation and drainage features.

- Construction projects of roads, highways, bridges and airports should implement approved erosion and sediment control plans prior to construction to reduce erosion and improve retention of sediments onsite during and after construction.

- Construction site chemical control measures for roads, highways, and bridges should limit toxic and nutrient loadings at construction sites by ensuring the proper use, storage, and disposal of toxic materials to prevent significant chemical and nutrient runoff to surface waters.

- Operation and maintenance activities for roads, highways, bridges, and airports should be developed so as to reduce pollutant loadings to receiving waters during operation and maintenance.

- Runoff systems should be developed for roads, highways, bridges, and airports to reduce pollutant concentrations in runoff from existing roads, highways, and bridges. Runoff management systems should identify priority pollutant reduction opportunities and schedule implementation of retrofit projects to protect impacted areas and threatened surface waters.

- The planning process for new and maintenance channel dredging projects should include an evaluation of the potential effects on the physical and chemical characteristics of surface waters that may occur as a result of the proposed work and reduce undesirable impacts. When the operation and maintenance programs for existing modified channels are reviewed, they should identify and implement any available opportunities to improve the physical and chemical characteristics of surface waters in those channels.

- Bridges should be designed to include collection systems which convey surface water runoff to land-based sedimentation basins.

- Sewage treatment discharges should be treated to meet state water quality standards. Implementation of up-to-date methodologies for reducing discharges of biocides (e.g. chlorine) and other toxic substances is encouraged.

- Use of land treatment and upland disposal/storage techniques of solid waste from sewage treatment should be implemented where possible. Use of vegetated wetlands as natural filters and pollutant assimilators for large scale wastewater discharges should be limited to those instances where wetlands have been specifically created for this purpose. The use of such constructed wetlands for water treatment should be encouraged wherever the overall environmental and ecological suitability of such an action can been demonstrated.

- Sewage discharge points in coastal waters should be located well away from critical habitats. Proposals to locate outfalls in coastal waters must be accompanied by hydrographic studies that demonstrate year round dispersal characteristics and provide proof that effluents will not reach or affect fragile and productive habitats.

- Dechlorination facilities or lagoon effluent holding facilities should be used to destroy chlorine at sewage treatment plants.

- No toxic substances in concentrations harmful (synergistically or otherwise) to humans, fish, wildlife, and aquatic life should be discharged. The EPA's Water Quality Criteria Series should be used as a guideline for determining harmful concentration levels. Use of the best available technology to control industrial waste water discharges should be required in areas adjacent to habitats essential to billfish. Any new potential discharge that will influence billfish EFH must be shown not to have a harmful effect on billfish or their habitat.

- The siting of industries requiring water diversions and large-volume water withdrawals should be avoided in areas influencing billfish EFH. Project proponents should demonstrate that project implementation will not negatively affect billfish, their EFH, or their food supply. Where such facilities currently exist, best management practices should be employed to minimize adverse effects on the aquatic environment.

- All NPDES permits should be reviewed and strictly enforced in areas affecting billfish EFH.

- Hazardous waste sites should be cleaned up (i.e., remediated) to prevent contaminants from entering aquatic food chains. Remedial actions affecting aquatic and wetland habitats should be designed to facilitate restoration of ecological functions and values.

4.4.2.4 Dredging and Disposal of Dredge Material

Dredging operations occur in estuaries, nearshore areas, and offshore in order to maintain certain areas for activities such as shipping, boating, construction of infrastructure (e.g., offshore oil and gas pipelines), and marine mining. Placement or disposal of the dredged material takes place in designated open water disposal areas, often near the dredge site. These operations can result in negative impacts on the marine environment. Of particular concern regarding billfish that move inshore is the temporary degradation of water quality due to the resuspension of bottom materials, resulting in water column turbidity, potential contamination due to the release of toxic substances (metals and organics), and reduced oxygen levels due to the release of oxygen-consuming substances (e.g., nutrients, sulfides). Even with the use of approved practices and disposal sites, ocean disposal of dredged materials is expected to cause environmental harm since contaminants will continue to be released, and localized turbidity plumes and reduced oxygen zones may persist.

Conservation Measures:

- Best engineering and management practices (e.g., seasonal restrictions, modified dredging methods, disposal options) should be employed for all dredging and in-water construction projects. Such projects should be permitted only for water dependent purposes when no feasible alternatives are available. Mitigating or compensating measures should be employed where significant adverse impacts are unavoidable. Project proponents should demonstrate that project implementation will not negatively affect billfish, their EFH, or their food sources.

- Project guidelines should make allowances to cease operations or take additional precautions to avoid adversely affecting billfish EFH during seasons when sensitive billfish life stages might be most susceptible to disruption (e.g., seasons when spawning is occurring).

- When projects are considered and in review for open water disposal permits for dredged material, Federal permitting agencies should identify the direct and indirect impacts such projects may have on billfish EFH.

- Uncontaminated dredged material may be viewed as a potentially reusable resource if properly placed and beneficial uses of these materials should be investigated. Materials that are suitable for beach nourishment, marsh construction or other beneficial purposes should be utilized for these purposes as long as the design of the project minimizes impacts on billfish EFH.

- "Beneficial Use" proposals in areas of billfish EFH should be compatible with existing uses by billfish. If no beneficial uses are identified, dredged material should be placed in contained upland sites. The capacity of these disposal areas should be used to the fullest extent possible. This may necessitate dewatering of the material or increasing the elevation of embankments to augment the holding capacity of the site. Techniques could be applied that render dredged material suitable for export or for use in re-establishing wetland vegetation.

- No unconfined disposal of contaminated dredge material should be allowed in billfish EFH.

- Disposal sites should be located in uplands when possible.

4.4.2.5 Agriculture (and Silviculture)

Agricultural and silvicultural practices can affect estuarine and coastal water quality through nutrient enrichment and chemical contamination from animal wastes, fertilizers, pesticides and other chemicals via non-point source runoff or via drainage systems that serve as conduits for contaminant discharge into natural waterways. In addition, uncontrolled or improper irrigation practices can contribute to non-point source pollution, and may exacerbate contaminant flushing into coastal waters. Major impacts also include nutrient over-enrichment with subsequent deoxygenation of surface waters, algal blooms - which can also produce hypoxic or anoxic conditions - and stimulation of toxic dinoflagellate growth. Excessively enriched waters often will not support fish, and also may not support food web assemblages and other ecological assemblages needed to sustain desirable species and populations. Agricultural activities also can increase sediment transport in adjacent water bodies, resulting in high turbidity. Many of these same concerns may apply to silviculture, as well.

Conservation Measures:

- Federal agencies, in conjunction with state agencies, should establish and approve criteria for vegetated buffer strips in agricultural areas that may affect billfish EFH in order to minimize pesticide, fertilizer, and sediment loads to these areas critical for billfish survival. The effective width of these vegetated buffer strips should vary with the slope of the terrain and soil permeability.

- Concerned Federal agencies (e.g., The Natural Resources Conservation Service) should conduct programs and demonstration projects to educate farmers on improved agricultural practices that would minimize the use and wastage of pesticides, fertilizers, and top soil, and reduce the adverse effects of these materials on billfish EFH.

- Delivery of sediment from agricultural lands to receiving waters should be minimized. Land owners have a choice of one of two approaches: (1) apply the erosion component of the U.S. Department of Agriculture's Conservation Management System through such practices as conservation tillage, strip cropping, contour farming, and terracing; or (2) design and install a combination of practices to remove settleable solids and associated pollutants in runoff for all but the largest storms.

- New and existing confined animal facilities should be designed to limit discharges to waters of the United States by storing wastewater and runoff caused by all storms up to and including the 25-year frequency storms. For smaller existing facilities the management systems that collect solids, reduce contaminant concentrations, and reduce runoff should be designed and implemented to minimize the discharge of contaminants in both facility wastewater and runoff caused by all storms up to and including 25-year frequency storms.

- Stored runoff and solids should be managed through proper waste utilization and the use of disposal methods which minimize impacts to surface and ground water.

- Development and implementation of comprehensive nutrient management plans should be undertaken, including development of a nutrient budget for the crop, identification of the types and amounts of nutrients necessary to produce a crop based on realistic crop yield expectations, and an identification of the environmental hazards of the site.

- Pesticide and herbicide management should minimize water quality problems by reducing pesticide use, improving the timing and efficiency of application (not within 24 hours of expected rain or irrigation), preventing backflow of pesticides into water supplies, and improving calibration of pesticide spray equipment. Improved methods should be used such as integrated pest management (IPM) strategies. IPM strategies include evaluating current pest problems in relation to the cropping history, previous pest control measures, and applying pesticides only when an economic benefit to the producer will be achieved (i.e., application based on economic thresholds). If pesticide applications are necessary, pesticides should be selected based on consideration of their environmental impacts such as persistence, toxicity, and leaching potential.

- Livestock grazing should protect sensitive areas, including streambanks, wetlands, estuaries, ponds, lake shores, and riparian zones. Protection is to be achieved with improved grazing management that reduces the physical damage and direct loading of animal waste and sediment to sensitive areas, i.e., by restricting livestock access or providing stream crossings.

- Upland erosion should be reduced by either applying the range and pasture components of a Conservation Management System, or maintaining the land in accordance with the activity plans established by either the Bureau of Land Management or the Forest Service. Such techniques include the restriction of livestock from sensitive areas through locating salt, shade, and alternative drinking sources away from sensitive areas, and providing livestock stream crossings.

- Irrigation systems that deliver necessary quantities of water yet reduce non-point source pollution to surface waters and groundwater should be developed and implemented.

- BMPs should be implemented to minimize habitat impacts when agricultural ditches are excavated through wetlands that drain to billfish EFH.

- NPDES/SPDES permits, in consultation with state fishery agencies, should be required for agricultural ditch systems that discharge into areas adjacent to billfish EFH.

4.4.2.6 Aquaculture and Mariculture

Aquaculture is an expanding industry in the United States, with most facilities located in farmland, tidal, intertidal and coastal areas. Aquaculture related impacts that adversely affect the chemical and biological nature of coastal ecosystems include the discharge of excessive waste products and the release of exotic organisms and toxic substances. Problems resulting from the introduction of food and fecal wastes may be similar to those resulting from certain agricultural activities. However, greater nutrient input and localized eutrophic conditions are currently the most probable environmental effects of aquaculture activities. Extremely low oxygen levels and fish kills, of both natural stocks and cultured fish, have been known to occur in impounded wetlands where tidal and wind circulation are severely limited and the enclosed waters are subject to solar heating. In addition, there are impacts related to the dredging and filling of wetlands and other coastal habitats, as well as other modifications of wetlands and waters, through the introduction of pens, nets, and other containment and production devices.

Conservation Measures:

- Mariculture operations should be located, designed and operated to reduce, prevent, or eliminate adverse impacts on estuarine and marine habitats and native fishery stocks. Those impacts that cannot be eliminated should be fully mitigated in-kind.

- Mariculture facilities should be operated in a manner that minimizes impacts on the local environment by utilizing water conservation practices and effluent discharge standards that protect existing designated uses of receiving waters.

- Federal and state agencies should cooperatively promulgate and enforce measures to ensure that diseases from culture operations do not adversely affect wild stocks. Animals that are to be moved from one biogeographic area to another or to natural waters should be quarantined to prevent disease transmission.

- To prevent disruption of natural aquatic communities, cultured organisms should not be allowed to escape; the use of organisms native to each facility's region is strongly encouraged.

- Commercial aquaculture facilities and enhancement programs should consider the genetic make-up of the cultured organisms in order to protect the genetic integrity of native fishes.

- Aquaculture facilities should meet prevailing environmental standards for wastewater treatment and sludge control.

4.4.2.7 Navigation

Navigation-related threats to estuarine, coastal, and offshore environments that have the potential to affect billfish EFH include navigation support activities, such as: excavation and maintenance of channels (including disposal of excavated sediments), which result in the elevation of turbidity and resuspension of contaminants; construction and operation of ports, mooring and cargo facilities; construction of ship repair facilities; construction of channel stabilization structures such as jetties and revetments. In offshore locations the disposal of dredged material is the most significant navigation related threat, resulting in localized burial of benthic communities and degradation of water quality. In addition, threats to both nearshore and offshore waters are posed by vessel operation activities such as the discharge and spillage of oil, other hazardous materials, trash and cargo, all of which may result in localized water quality degradation and direct effects on billfish, especially eggs and larvae, that may be present. Wakes from vessel operation may also exacerbate shoreline erosion, effecting habitat modification and potential degradation.

Conservation Measures:

- Permanent dredged material disposal sites should be located in upland areas. Where long-term maintenance is anticipated, upland disposal sites should be acquired and maintained for the entire project life.

- Construction techniques (e.g., silt curtains) should minimize turbidity and dispersal of dredged materials into billfish EFH.

- Propwashing should not be used as a dredging method.

- Channels and access canals should not be constructed in areas known to have high sediment contamination levels. If construction must occur in these areas, specific techniques including the use of silt curtains are needed to contain suspended contaminants.

- Alignments of channels and access canals should utilize existing channels, canals and other deep water areas to minimize initial and maintenance dredging requirements. All canals and channels should be clearly marked to avoid damage to adjacent bottoms from propwashing.

- Access channels and canals should be designed to ensure adequate flushing to avoid creating low dissolved oxygen conditions or sumps for heavy metals and other contaminants. Widths of access channels in open water should be minimized to avoid impacts to aquatic substrate. In canal subdivisions channels and canals within the development should be no deeper than the parent body of water and should be a uniform depth or become gradually shallower inland.

- To ensure adequate circulation confined and dead-end canals should be avoided by utilizing bridges or culverts that ensure exchange of the entire water column. In general, depths of canals should be minimized, widths maximized, and canals oriented towards the prevailing summer winds in order to enhance water exchange.

- Consideration should be given to the use of locks in navigation channels and access canals which connect more saline areas to fresher areas.

- To the maximum extent practicable, all navigation channels and access canals should be backfilled upon abandonment and restored to as near pre-project condition as possible. Plugs, weirs or other water control structures may also be necessary as determined on a case-by-case basis.

- All vessels transporting fuels and other hazardous materials should be required to carry equipment to contain and retrieve the spill.

- Dispersants should not be used to clean up fuels and hazardous materials unless approved by the EPA/Coast Guard after consultation with fisheries agencies.

4.4.2.8 Marinas and Recreational Boating

Marinas and recreational boating are increasingly popular uses of coastal areas. As marinas are located at the water's edge, there is often no buffering of associated pollutants released into the water column. Impacts caused by marinas include lowered dissolved oxygen, increased temperatures, bioaccumulation of pollutants by organisms, toxic contamination of water and sediments, resuspension of sediments and toxics during construction, eutrophication, change in circulation patterns, shoaling, and shoreline erosion. Pollutants that result from marina activities include nutrients, metals including copper released from antifouling paints, petroleum hydrocarbons, pathogens, and polychlorinated biphenyls. Also, chemicals commonly used to treat timber used for piers and bulkheads - creosote, copper, chromium, and arsenic salts - are introduced into the water. Other impacts associated with recreational boating are the result of improper sewage disposal, fuel and oil spillage, cleaning operations, and disposal of fish waste. Propellers from boats can also cause direct damage to multiple life stages of organisms, including: eggs, larvae/neonates, juveniles, and adults; destratification; elevated temperatures, and increased turbidity and contaminants by resuspending bottom materials.

Conservation Measures:

- Water quality must be considered in the siting and design of both new and expanding marinas.

- Marinas are best created from excavated uplands that are designed so that water quality degradation does not occur. Applicants should consider basin flushing characteristics and other design features such as surface and waste water collection and treatment facilities. Marina siting and design should allow for maximum flushing of the site. Adequate flushing reduces the potential for the stagnation of water in a marina and helps to maintain the biological productivity and reduce the potential for toxic accumulation in bottom sediments. Catchment basins for collecting and storing runoff should be included as components of the site development plan.

- Marinas should be designed and located so as to protect against adverse impacts on important habitat areas as designated by local, state, or Federal governments.

- Where shoreline erosion is a non-point source pollution problem, shorelines should be stabilized. Vegetative methods are strongly preferred.

- Runoff control strategies, which include the use of pollution prevention activities and the proper design of hull maintenance areas, should be implemented at marina sites.

- Marinas with fueling facilities should be designed to include measures for reducing oil and gas spillage into the aquatic environment. Fueling stations should be located and designed so that in the case of an accident spill contaminants can be contained in a limited area. Fueling stations should have fuel containment equipment as well as a spill contingency plan.

- To prevent the discharge of sewage directly to coastal waters new and expanding marinas should install pumpout, pump station, and restroom facilities where needed. Pumpout facilities should be maintained in operational condition and their use should be encouraged to reduce untreated sewage discharges to surface waters.

- Solid wastes produced by the operation, cleaning, maintenance, and repair of boats should be properly disposed of to limit their entry to surface waters.

- Sound fish waste management should be part of the project design, including a combination of fish cleaning restrictions, public education, and proper disposal facilities.

- Appropriate storage, transfer, containment, and disposal facilities for liquid materials commonly used in boat maintenance, along with the encouragement of recycling these materials, should be required.

- The amount of fuel and oil leakage from fuel tank air vents should be reduced.

- Potentially harmful hull cleaners and bottom paints and (their release into marinas and coastal waters) should be minimized.

- Public education/outreach/training programs should be instituted for boaters, as well as marina operators, to prevent improper disposal of polluting materials.

4.4.2.9 Ocean Dumping

The disposal of dredged sediments and hazardous and/or toxic materials (e.g., industrial wastes) containing concentrations of heavy metals, pesticides, petroleum products, radioactive wastes, pathogens, etc., in the ocean degrades water quality and benthic habitats. These effects may be evident not only within the immediate vicinity of the dumping activity, but also at farther locations, as well, due to current transport and the potential influence of other hydrographic features. The disposal of uncontaminated dredged material, including adverse effects on EFH and appropriate conservation measures are addressed in Section 4.4.2.3 of this chapter. Disposal of hazardous and toxic materials by U.S. flag vessels and vessels operating in the U.S. territorial sea and contiguous zone is currently prohibited under the Marine Protection Research and Sanctuaries Act (MPRSA), although under certain circumstances the Environmental Protection Agency may issue emergency permits for dumping industrial wastes into the ocean. Major dumping threats to the marine environment are therefore limited mostly to illegal dumping and accidental disposal of material in unauthorized locations. However, given the amount of debris that is deposited along the Nation's beaches every year, including hazardous materials such as medical wastes, it is evident that effects from such dumping may be substantial.

Conservation Measures:

- Federal and state agencies mandated with ocean dumping enforcement responsibilities should continue to implement and enforce all legislation, rules and regulations, and consider increasing monitoring efforts where warranted.

- Disposal of hazardous materials within areas designated as EFH for billfish should not be allowed under any circumstances, including emergency permit situations.

4.4.3 Cumulative Impacts

The EFH regulations suggest that cumulative impacts should be analyzed for adverse effects on EFH. Cumulative impact analysis is a locale-specific activity that will be undertaken as additional information on specific habitat locations and threats to that habitat can be accessed, and as additional spatial techniques are developed to properly analyze that information. For this amendment cumulative impacts will be addressed by describing the types of threats and effects that have been documented to have adverse effects on fish habitat, cumulatively.

Cumulative impacts on the environment are those that result from the incremental impact of actions added to other past, present and reasonably foreseeable future actions. Such cumulative impacts generally occur in inshore and estuarine areas, and can result from individually minor, but collectively significant, actions taking place over a period of time. These impacts include water quality degradation due to nutrient enrichment, other organic and inorganic contaminants associated with coastal development, activities related to marine transportation, and loss of coastal habitats, including wetlands and sea grasses. The rate and magnitude of these human-induced changes on EFH, whether cumulative, synergistic, or individually large, is influenced by natural parameters such as temperature, wind, currents, rainfall, salinity, etc. Consequently, the level of threat posed by a particular activity or group of activities may vary considerably from location to location. These multiple effects can, however, result in adverse impacts on billfish EFH.

Nutrient enrichment has become a major cumulative problem for many coastal waters. Nutrient loading results from the individual activities of coastal development, non-point source pollution, marinas and recreational boating, sewage treatment and disposal, industrial wastewater and solid wastes, ocean disposal, agriculture and aquaculture. Excess nutrients from land based activities may accumulate in the soil, be transported through the atmosphere, pollute ground water, or move into streams and coastal waters. Nutrient inputs are known to have a direct effect on water quality. For example, in extreme conditions excess nutrients can stimulate excessive algal blooms or dinoflagellate growth that can lead to increased metabolism and turbidity, decreased dissolved oxygen, and changes in community structure, a condition known as eutrophication. Examples of such dinoflagellates or algae include *Gymnodinium breve*, the dinoflagellate that cause neurotoxic shellfish poisoning, dinoflagellates of the genus *Alexandrium* which causes paralytic shellfish poisoning, *Aureococcus anophagefferens* the algae which cause "brown tides", and diatoms of the genus *Pseudo-nitzschia* which cause amnesic shellfish poisoning. A *Pfiesteria* *piscicida*-like organism has been documented in St. John's River, Florida. This organism has been associated with fish kills in some areas.

In addition to the direct cumulative effects incurred by development activities, inshore and coastal habitiats are also jeopardized by persistent increases in certain chemical discharges. The combination of incremental losses of wetland habitat, changes in hydrology, and nutrient and chemical inputs produced over time can be extremely harmful to marine and estuarine biota, resulting in diseases and declines in the abundance and quality of the affected resources.

Future investigations will seek to analyze cumulative impacts within specific geographic locations (certain estuarine, coastal and offshore habitats) in order to evaluate the cumulative impacts on billfish EFH. Information and techniques that are developed for this process will be used to supplement future revisions of these EFH provisions as the information becomes available.

Conservation Measures:

- Conservation measures for individual activities that contribute to cumulative impacts are covered in the previous sections. Participation in watershed scale planning efforts should be encouraged.

4.5 Research and Information Needs

During the identification of EFH for the billfish covered in this amendment, numerous information gaps were also identified. This was not unexpected considering the broad distribution of these species in oceanic and nearshore habitats as well as their pelagic nature. In many cases, the movements of these animals are poorly understood or have only been defined in broad terms. Furthermore, although the habitats through which these animals transit may be intensely studied, and the physical and biological processes fairly well understood in broad terms, there is little understanding of the particular characteristics that influence the distribution of billfish within those systems. Unlike many estuarine or coral reef species that can be easily observed, collected or cultured, the extensive mobility and elusiveness of the species, combined with their rarity, has delayed the generation of much of the basic biological and ecological information needed to analyze their habitat affinities. Moreover, there is a general lack of technology to study habitat associations of these species *in situ*, as well as in laboratory cultures.

Based on the present state of information concerning the habitat associations of billfish, the following research and information needs have been identified. The NMFS National Habitat Research Plan lays out a framework within which research priorities may be grouped. Many of the research and information needs for billfish fit well within that plan, and it has been used to define general topics for research and information collection.

Ecosystem Structure and Function

- Investigate the influence of habitat characteristics such as temperature (e.g., the relation to thermal fronts) and salinity on billfish distributions, spatially as well as seasonally.

- Monitor animal movements using advanced archival and satellite telemetry technology in order to better define billfish distributions, seasonality, environmental tolerances and preferred habitats.

- Identify spawning areas and investigate the role of environmental factors which affect distribution and survival of larvae and juveniles, leading to variations in year class abundance.

- Characterize submarine canyon processes, eddies, gyres, and fronts as they interact with billfish, and characterize their importance as zones of aggregation.

- Further identify major prey species for billfish (by species), including preferred feeding areas and influences of environmental factors.

- Gain a better understanding of the life history of billfish; including the development of culture methods to keep billfish alive in captivity for life history studies.

- Improve the capability to identify eggs and early life stages of the billfish species.

Effects of Habitat Alteration

- Investigate the effects of contaminants on billfish life stages, especially eggs and larvae; this would require the development of better laboratory culture techniques for these species.

- Determine the effects of contaminants (e.g., oil spills) in offshore epipelagic habitats where billfish are known to spawn or otherwise aggregate.

- Identify habitat linkages between inshore and offshore habitats to better define the zone of influence for inshore activities that may adversely affect billfish habitats.

Synthesis and Information Transfer

- Incorporate/develop spatially consistent databases of environmental conditions throughout the billfish ranges (e.g., temperature, salinity, currents).

- Further analyze fishery dependent data to construct a clearer view of relative abundances.

- Contour abundance information to better visualize areas where billfish are most commonly encountered.

- Construct spatial databases for early life history stages (i.e., eggs and larvae).

- Derive objective criteria to model areas of likelihood for relative abundances of billfish based on environmental parameters.

- Define and model habitat suitability based on seasonal analyses of tolerances of environmental conditions.

4.6 Review and Revision of EFH Components

Throughout the preparation of this document, numerous sources of information have been identified. Some of these have been accessed and incorporated into the identification and description of billfish EFH for this amendment. These sources include fishery scientists both inside and outside of NMFS and databases maintained in the NMFS Southeast Fisheries Science Center (SEFSC) in Miami, FL (e.g., Billfish RBS, Pelagic Longline Logbook, Observer Program, Large Pelagic Survey, etc.). The most up-to-date and reliable information available was used to describe and identify EFH for billfish in this amendment. NMFS will continue to identify other sources of information that can be incorporated into these analyses to further refine EFH. Other data sources might include ichthyoplankton sampling efforts for the Gulf of Mexico and other on-going investigations that will provide additional insight into the distribution of billfish. The Release and Recapture (CTC) databases used for this amendment are part of a continuing effort to monitor these fisheries over broad spatial scales. They are continually being updated with newly reported information and are being scrutinized to ensure that a high standard is maintained. Additional analytical techniques and database queries will be possible to more fully evaluate trends and patterns in the data such as seasonal, inter-annual and inter-decadal variations. Because the database incorporates such a long time series of data, it may allow for additional investigation of the historic ranges and temporal changes in species distributions.

The tagging, catch and bycatch information used from these databases for preparation of the EFH provisions of this amendment are part of a continuing effort to monitor billfish and other highly migratory species fisheries over broad spatial scales. They are continually updated with newly reported information and scrutinized to ensure that a high standard is maintained. Additional analytical techniques and database queries will be possible to more fully evaluate trends and patterns in the data such as seasonal, inter-annual and inter-decadal variations. Because these databases incorporate such long time series of data, additional investigations of the historic ranges and temporal changes in species distributions should be possible in the future.

NMFS is committed to monitoring and participating in these on-going research efforts in order to update the information in the EFH provisions of this amendment. New and updated information, if available, will be reviewed as part of the annual Stock Assessment and Fishery Evaluation (SAFE) Report prepared by NMFS. If the additional information provides significant improvement over the current document, NMFS will consult with the Billfish Advisory Panel and, if warranted, prepare an amendment to refine the EFH descriptions and threats and conservation sections of the EFH provisions of this amendment.

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